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SCIENTIFIC AND INDUSTRIAL RESEARCH IN GOVERNMENT DEPARTMENTS

IN its fifth report for the Session 1957–58* the Select Committee on Estimates considers the work of the Department of Scientific and Industrial Research. It is, however, limited to the work carried out directly by the Department through its fourteen experimental establishments. no comment is offered on the Department's work in relation to the universities, although this was considered in evidence submitted to the Committee. Moreover, apart from the single recommendation that the admissible reasons for refusing applications for membership of a research association should be explicitly stated in the terms of grant, and that the councils of the research associations should be required to furnish a list annually of the applications which they have rejected, with reasons, the work of the research associations is likewise only noted in evidence. Indeed, the Select Committee professes itself to be satisfied, in general, with the working of the research association scheme. Its report therefore deals solely with the organization and administration of the Department from the point of view of the Council's expenditure of the appropriate vote, and is thus in fact concerned with the sum of £5,775,587 gross expended on the fourteen experimental establishments out of the Department's gross estimate for 1958–59 of £10,472,993, though its criticisms and comments inevitably include also the headquarters expenditure of £537,206.

It will be seen from the foregoing alone that the Select Committee does not attempt to assess the place of the Department in Britain's general organization for research and development. The lacuna left two years and more ago by the Jephcott Committee remains unfilled, and although the Select Committee on Estimates makes a number of sensible suggestions, these might have been expected to have come from the Advisory Council on Scientific Policy. Such reference to the Advisory Council as is made in this report, which touches so closely on the responsibilities of both the Advisory Council and the Lord President of the Council, seems to endorse Sir Hugh Beaver's strong criticisms early this year. Furthermore, it is surprising that the work of the Department should have been submitted to a searching examination so soon after the report of the Jephcott Committee and the subsequent re-organization of the Department.

It is not that the Department comes badly out of this review. On the contrary, the Select Committee on Estimates recognizes that the new Executive Council of the Department is already engaged in a full-scale review of the work of all its establishments and has begun to re-shape and re-formulate policy. Indeed, it admits that many criticisms which might have been levelled against the Department's general organization as lately as November 1957, when the present inquiry began, had been rendered out of date by July 1958. Specifically it wholeheartedly welcomes the initiative of the Council in undertaking its present review and in establishing a policy of continuous reviews as likely to facilitate proper timing in terminating a piece of research—an operation as important as timing its institution and possibly more difficult as well as less frequently practised.

Apart from this general comment, the Estimates Committee's remarks relate to the relations of the Department with other government departments and with industry, and it is the other departments that incur the gravamen of its criticism. Four of the Department's experimental establishments differ from the other ten in that they work mainly for one particular government department, and of these four, the Road Research Laboratory was studied in some detail. Apart from its work for the Colonial Office, the Laboratory's work is principally on behalf of the Ministry of Transport and Civil Aviation, and although the Committee was satisfied with the liaison between the two departments, it comments trenchantly that contracts for road construction are only very exceptionally shown to the Laboratory. Without seeing the actual prices quoted, the Committee points out, the Laboratory's experts can scarcely be satisfied that the new practices they have recommended are properly understood and any financial savings made possible by these practices are in fact being achieved, nor can the Laboratory be sure that their recommendations are used unless regular reports are made to them about costs of construction and subsequent performance. Accordingly, the Committee recommends that, quite apart from other considerations, the tenders received by the Ministry of Transport and Civil Aviation from contractors for work to be done to new specifications should be shown to the Laboratory as a matter of routine, and that steps should be taken to inform the Laboratory of the performance in practice of construction in accordance with new specifications.

Nevertheless, however perfect the liaison between two departments, the Select Committee believes that, where practicable, amalgamation of two related departments is preferable. On the evidence it received, the Committee leans strongly to the view that the Road Research Laboratory would better be placed under the Ministry of Transport and Civil Aviation. This would ensure that the Ministry was aware in advance of what staff and facilities are available and reduce the risk of drawing up research schemes which cannot be undertaken. It should also facilitate the dissemination of the results of the research where they are most likely to be used to advantage. The Ministry, it believes, is in a better position to do this than the Department of Scientific and Industrial Research, just as it could better judge

* Fifth Report from the Select Committee on Estimates together with part of the Minutes of the Evidence taken before Sub-Committee B and Appendices, Session 1957–58—The Department of Scientific and Industrial Research. Pp. xvi+165. (London: H.M. Stationery Office, 1958.) 9s. net.

priorities in work affecting its own department; fundamental research at present carried out by the Laboratory could equally well be carried out by the Building Research Station. The Committee quite rightly notes that such fundamental work is likely to apply to a wider field than that of road construction, but it seems to have overlooked the value of fundamental and applied research proceeding side by side in the one laboratory, from the point of view of attracting and retaining staff and of stimulating new ideas. In regard to the former, it was stated in the evidence that the scientific and experimental staff is at present some 7·5 per cent below strength, and that younger men are attracted to places where the research programmes are most interesting.

The Select Committee, however, is content here with the general recommendation that the Government should specifically consider the question which Department should control the Pest Infestation Laboratory, the Radio Research Station, the Road Research Laboratory and the Water Pollution Research Laboratory. The recommendation is clearly in line with the trend of policy which the new Council has already indicated in its first annual report; but it also suggests that the whole question of the organization of the national research effort is being re-opened and requires consideration from very much wider angles than those of a department. That is also implied in the recommendations relating to co-operation between the Admiralty and the Department of Scientific and Industrial Research; though here, as in its fifth report for the session 1956–57, the Committee is critical of the Admiralty rather than the Department.

The Select Committee accepts the Admiralty's view that problems of ship design and propeller design (see also *Nature*, October 11, p. 988) may differ considerably for warships and merchant ships; but it believes that much greater efforts are required to promote consultation and liaison between the scientists concerned, in order to avoid unnecessary duplication of effort and uneconomic use of facilities, quite apart from the question of availability of knowledge. While the Committee is satisfied that Admiralty knowledge and opinion are fully available to the Department at the most important stage for avoiding overlapping—when the Department's research programme is drafted—the complementary process does not occur, nor are the provisions for making available to the Department the knowledge in the Admiralty's possession satisfactory. The Department of Scientific and Industrial Research has no *ex officio* members of any committee in the Admiralty which plans research, and no opportunity of commenting on the programme which the Admiralty proposes to carry out in their tank at Haslar. Further, no real attempt is made to co-ordinate the use of available facilities for research on ship and propeller design.

Accordingly, the Estimates Committee refuses to accept the view that considerations of secrecy should preclude senior officers of the Department of Scientific and Industrial Research from knowledge of the Admiralty's research plans and makes the following recommendations. First, that the Admiralty should in future afford some officers of the Department an opportunity of commenting on the Admiralty's programme of ship and propeller research at the earliest possible stage, and certainly before the programme is finally settled. Secondly, the Admiralty and the Department should work out a scheme for the regular use of all the available facilities for research in this field by both departments. Thirdly, selected officers of the Department of Scientific and Industrial Research should be given free access to all the scientific information relating to ship and propeller design at present in possession of the Admiralty which the Admiralty would be prepared to disclose if it were specifically requested.

These are sensible recommendations, which, quite apart from their value in checking undesirable secrecy, are in harmony with those which the Select Committee made in the previous session. They point, moreover, to the importance of much closer co-operation between the Defence Research Policy Committee and the Advisory Council for Scientific Policy. If that liaison were in fact satisfactory, it is difficult to see how such recommendations as these could have been left to the Select Committee on Estimates.

BOOKS ON EVOLUTION

Evolution by Natural Selection

By Charles Darwin and Alfred Russel Wallace. Pp. viii+288. (London: Cambridge University Press, 1958. Published for the XV International Congress of Zoology and the Linnean Society of London.) 25*s*. net.

Darwin's Century

Evolution and the Men Who Discovered It. By Prof. Loren Eiseley. Pp. xvii+378. (New York: Doubleday and Company, Inc., 1958.) 5 dollars.

A Century of Darwin

Edited by S. A. Barnett. Pp. xvi+376+5 plates. (London: William Heinemann, Ltd., 1958.) 30*s*. net.

Embryos and Ancestors

By Sir Gavin de Beer. Third edition. Pp. xii+197. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 25*s*. net.

THESE books are some of the many published during the past year in response to the renewed interest in Darwin and his work stirred up by the centenary of the meeting of the Linnean Society in 1858 at which he and Wallace first published the theory of natural selection.

The first book contains reprints of Darwin's essays of 1842 and 1844, which he did not publish, and of the papers given to the Linnean Society. It is prefaced by a short discussion of the present position by Sir Gavin de Beer and by an introduction written by Sir Francis Darwin for the essays when they were published in 1909.

It is useful to have these classical writings in an easily accessible form. They are important for the history of Darwin's thought and especially in showing

how clearly he was able to outline his theory in 1842 after no more than five years work. The main part of his paper of 1858 was indeed an almost entirely unchanged extract from the essay of 1844. His views had been scarcely at all altered in the interval. This also appears from the many notes that are given correlating what is said in the essay with parallel passages in "The Origin".

The second book is a history of the development of belief in the fact of evolution and its theory in the nineteenth century. When he comes to write of early genetics, the author extends his account to the first few years of the present century, but he does not go further; we are told to expect a second volume carrying the story to the present day. The book is a scholarly and well-documented account of the subjects it deals with, but there are some omissions that seem surprising. The reactions in the world outside science are scarcely at all discussed. Perhaps, the author felt that his subject lay in the history of biology and that he should not concern himself with what happened elsewhere. But the interactions were undoubtedly mutual, and a full discussion of the course of events in biology requires some consideration of the development of thought in general.

Less easily understood are two other omissions. The author says very little of the transcendental theories of the early part of the nineteenth century. Darwin may not have been greatly influenced by the work of this type, for it was not his kind of zoology, but it was dominant in the years before he wrote "The Origin" and its theories certainly influenced the reactions of many zoologists to the new theory, especially in Germany (von Baer, Kölliker). Again, anyone reading the book without some previous knowledge would get the impression that the opposition of the early geneticists at the beginning of this century to the theory of evolution by natural selection was shared universally by the biologists of the time. The views of the many who denied the force of the Mendelian evidence against the theory—on the basis of their experience of animals and plants in Nature, of the nature of evolutionary change as seen in palæontological series of strata, and of results such as those of Galton on heredity in man—are not discussed.

All the same, the chapters of the book regarded as accounts of some aspects of the history are valuable, especially, perhaps, those on Darwin's reactions to the claims of the physicists to deny a longer history of the world than a few million years, and on his disagreement with Wallace over the evolution of man. The book should be read, and the appearance of a second volume will be awaited with interest.

The third book contains fifteen short articles by various authors, many of them eminent, on the present position in fields of the study of evolution with which they have been particularly concerned. Most of the contributions are valuable as being clear and concise summaries, but none of the authors has space to do more than this. In fact, the book as a whole suffers from the usual limitations of composite books of this kind. The articles will be useful to anyone who has a sound background of modern views of evolutionary theory, but it is less likely to be useful to those who lack this background of knowledge; no general view of the present position will be gained. It is not possible to discuss the separate articles in a short review such as this. One contribution, that of D. Michie, on "The Third Stage of Genetics" seems scarcely in place in a volume intended to review "the present status of Darwinian ideas in biology". In it views are expressed which would be unlikely to be endorsed by the majority of geneticists, at least in Britain and America.

The last of these books is less closely concerned with the centenary of the theory of natural selection. It is a revision of Sir Gavin de Beer's well-known book, first published in 1930. The argument is unaltered from earlier editions, but it is expanded with further examples in many places and with three additional chapters on embryology and taxonomy, embryology and homology, and the germ layers. The book is, throughout, concerned with re-interpretation of classical phylogenetic concepts in the light of modern knowledge and in particular with disproof of Haeckel's theory of recapitulation—more a flogging of a dead horse now than it was in 1930, largely owing to the earlier editions of this book—and of the cruder forms of the germ-layer theory. de Beer attributes much importance in evolution to the various types of neoteny, perhaps more than some zoologists would allow. It is good to have this restatement of his views.

G. S. CARTER

MODERN MICROSCOPY

X-ray Microscopy and Microradiography

Proceedings of a Symposium held at the Cavendish Laboratory, Cambridge, 1956. Pp. xviii+645. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 16.50 dollars.

DURING the post-war years, one of the major developments in the technique of scientific inquiry has been the spectacular development of microscopy. While electron microscopy undoubtedly scores on the grounds of the high resolution already achieved, the great penetration of X-rays in matter offers great promise in the extension of microscopy to X-ray wave-lengths. The present volume presents the full text of the papers delivered at the first symposium on X-ray microscopy and X-ray micrography together with short extracts of the discussions. All the current techniques of X-ray microscopy—contact X-ray microradiography, reflexion X-ray microscopy and point projection X-ray microscopy—are fully dealt with each by a number of authors distinguished in this field.

The first section deals with the basic principles of these three methods and points out the conditions under which each method finds its greatest application. The following three and several later chapters, referring as they do to the construction of the necessary apparatus including X-ray tubes, will be of greater interest to the experimental physicist than to the prospective user, but nevertheless form a coherent and instructive series. In other chapters methods and techniques are dealt with fully and some applications in biological, medical and metallurgical fields are described.

The total effect left on reading this book is that here is a technique which has not yet reached full bloom but is advancing rapidly. Both contact X-ray microradiography and point projection X-ray microscopy already yield images with resolution at least as good as that in light microscopy, and indications are given that the resolution in the former (also the easier) method is even now so high that attempts are being made to enable the magnification of the original contact image to be achieved in an electron micro-

scope in place of a light microscope. The discussion of reflexion X-ray microscopy is, however, on the whole discouraging.

The papers are somewhat uneven in quality, as might be expected in the unabridged presentation of articles by a large number of authors but, on the whole, the book reads remarkably smoothly and the editors are to be complimented on a compilation which welds the diverse contributions into a coherent whole. The book well repays close study by all workers, particularly biologists, interested in future developments in microscopy. R. D. Preston

MODERN CYTOLOGY

International Review of Cytology, Vol. 6
Edited by G. H. Bourne and Prof. J. F. Danielli. Pp. x+566. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 12 dollars.

THIS volume contains twelve essays in various fields of cytology, the whole forming a very valuable contribution to knowledge. In some cases the subjects dealt with have advanced so rapidly since the manuscripts were received that their authors could have wished to have been able to add to their conclusions. The antigens of *Paramecia* were first studied so far back as 1905 by Rössle, who showed that rabbits immunized against these Protozoa developed antibodies capable of paralysing them. Sonneborn's discovery of the mating type system of *Paramecium aurelia* made possible further work on cellular processes in general. G. H. Beale of the Department of Animal Genetics, Edinburgh, now discusses the antigen system of *Paramecium*. Beale believes that the hypothesis of autonomous cytoplasmic states, and the hypothesis of variable gene activity, contain possible explanations of most, but not of all, of the known facts.

Sajiro Makino of Hokkaido University, Japan, writes about those remarkable ascites tumours of rats, which can be transferred from animal to animal by injecting a small amount of tumour ascites into the peritoneal cavity with a sharp pipette. Makino's work shows that the most frequently occurring tumour cells possess characteristic chromosome number modes, along with particular patterns, and form a stem-cell lineage, the members of which serve as the primary progenitors. Makino mentions tumours with distinct chromosome numbers—39, 66, 84, 91, etc.—which is a remarkable contribution to the study of cancer.

Arthur W. Pollister and Priscilla F. Pollister write on the structure of the Golgi apparatus. They state that Jan Hirschler originated the idea that the parts of the Golgi apparatus are formed of a thin lamella, or membrane. While we are all for bringing the work of Hirschler before the eyes of the impatient young men who have an electron microscope, we certainly do not consider that Hirschler knew that what he believed to be the lamelliform Golgi membrane was made up of a pile of separate lamellae or saccules usually of fairly definite number. That the blackened "nebenkern batonette" of molluscs is some kind of a multiple structure was first pointed out by Beams *et al.* What also seems important is that Hirschler in 1932, in the *Comptes rendus de la Société de biologie* (109, 1157), first described the *granulated* ergastoplasm in the spermatid of *Macrothylacia rubi*. Hirschler used material fixed in modified Hermann's fluid, then post-osmicated.

From Palermo comes an interesting article by A. Monroy on the fertilization and activation of the egg, and from Berkeley, California, by Robley Williams, a very full review in the role of the electron microscope in virus research. He writes, "We may hope for techniques that will allow us to put our finger on an image of a tiny particle, and say with some confidence that—this is a *virus* particle".

Arthur J. Hale of the University of Glasgow has sixty pages in the histochemistry of polysaccharides. Those who wish to read an authoritative discussion, for example, on the relationship between metachromasia, periodic acid–Schiff staining and polymerization, will find it here. J. Gross of the State University of New York has attempted to relate follicular structure of the thyroid gland to colloid turnover and iodine metabolism. He correlates our knowledge of the nature and function of the parafollicular cells.

Elio Borghese of the University of Cagliari, Italy, has provided a most useful article on the application of histochemical methods to embryonic tissues. One of the most remarkable contributions in this field was the discovery by Chiguoine in 1953 that the primordial genital cells could be recognized in the mouse embryo on the eighth day of gestation by their high alkaline phosphatase rate. This article is recommended for senior students of the comparative physiology of reproduction. R. J. O'Connor of the Westminster Medical School, London, has a speculative review of the information available about the metabolism of the early embryos of the amphibians, the chick, and the sea-urchin. His contribution can be read in conjunction with that of Borghese.

G. Siebert and R. M. S. Smellie of Johannes Gutenberg University, Mainz, and the University of Glasgow, respectively, have contributed an account of the biochemistry of isolated cell nuclei. Conveniently, the next essay by George H. Hogeboom, Edward L. Kuff and Walter C. Schneider is on the cytochemistry of tissue homogenates. These articles are on subjects which are advancing swiftly. George H. Hogeboom died on July 6, 1956, a great loss to his colleagues at Bethesda, and to this difficult and promising field of modern cytology.

The final article by Freda Bowyer of King's College, London, on the kinetics of the penetration of non-electrolytes into the mammalian erythrocyte, is an abstruse and masterly treatment of the problem of red cell transfer. At present no one has devised a decisive experiment which would eliminate any of the three postulated mechanisms—carrier, enzyme, or pore. J. Brontë Gatenby

AN APPROACH TO ORGANIC CHEMISTRY

A Modern Approach to Organic Chemistry
By Prof. J. Packer and J. Vaughan. Pp. x+973. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 84*s.* net.

THE teaching of a progressive science has been likened to "The Hunting of the Snark" in that the objective is indefinite, changing with time as major research achievements have to be incorporated within limited curricula, and dependent more on the enthusiasm than on the erudition of the teacher. However, a comprehensive text-book should provide a balanced guide to both teachers and students,

approaching the advancing front of the subject by the clearest possible route, avoiding laborious minutae of the past and showing circumspection in treatment of theories. In producing a new major text-book of organic chemistry the joint authors, from the University of Canterbury, New Zealand, deserve commendation both for the extent of their labours and for their general plan in attempting to teach essential facts through the clear presentation of electronic theories of molecular structure and reaction mechanisms.

The book is decidedly British in its educational outlook, rather than American or Swiss. The modern approach avoids the usual alternatives either of detailing nineteenth-century structural theories or of crowding an indigestible mass of facts into the opening chapters, and clearly presents in its first 150 pages most essential features of modern structural theories together with the homolytic and heterolytic mechanisms of reaction processes. It achieves this in chapters dealing, by title, with hydrocarbons, their halogen derivatives, and amines. Thereafter the volume deals with other functional groups in the conventional order, placing aromatic chemistry after 500 pages of aliphatic chemistry and ending with but 45 pages of heterocyclic chemistry. Proteins, terpenes, steroids, purines, alkaloids and natural colouring matters do not receive treatment, so that the lengthy volume is suited only to a limited curriculum.

The worst failing of old-fashioned text-books is repeated in that optical isomerization is not introduced until hydroxy-acids are dealt with among bifunctional molecules (p. 371). Walden inversion then gets brief mention (p. 390), though the S_N2 mechanism is described much earlier (p. 114). Consequently, one cannot find in the whole volume the important modern concept of the stereospecificity of bimolecular reaction processes, or even mention of *trans* addition and elimination reactions. Modern ideas of steric hindrance and molecular conformation are clearly beyond the scope of the book: structures for *cyclo*-hexane are correctly given on p. 41, though the interconversion of 'boat' and 'chair' forms is said to be tautomeric. Even later, in connexion with acetoacetic ester, no clear evidence is cited as to why tautomerism is believed to be an acid-base catalysed process, though the diagrams representing reaction mechanisms are correct.

The readable form and the typography of the volume have the invariable high standard of publications of the Clarendon Press, but the chapters on aromatic chemistry contain even more plain hexagons for benzene than Kekulé structures. The two symbolisms are found together even on the same page. It is fortunate, therefore, that the book does not include modern work on alicyclic compounds, since it is now conventional to restrict the use of the plain hexagon to denote the *cyclo*-hexane ring.

Yet, though the omissions from this book of several salient topics of importance cannot be overlooked, the volume does present in a clear, interesting fashion a very large bulk of important factual matter with which chemistry undergraduates need to become conversant. The authors have, in fact, taken a conventional text-book and have added to it, *seriatim*, electronic formulæ for the mechanism of each reaction described. They do this by following meticulously the authoritative guides provided by the monographs of Sidgwick and Ingold. By retaining tables of physical properties they endeavour to maintain comprehensive coverage for a degree course and hence bulk the pagination.

Thus in this essay at a modern text-book of organic chemistry the Bellmen have started on a true course, but their leadership has failed in mid-ocean. Firm handling, with judicious pruning and a wider objective, is needed to make this a text that will command wide respect.

W. A. WATERS

MICROSAUR RELATIONSHIPS

Revision of the Gymnarthridæ American Permian Microsaurs

By Joseph T. Gregory, Frank E. Peabody, and Llewellyn I. Price. (Peabody Museum of Natural History, Yale University, Bulletin 10.) Pp. x+77. (New Haven: Peabody Museum of Natural History, Yale University, 1956.) n.p.

THE Microsaurs are not 'little reptiles' as their name implies but are a group of ancient amphibians that must have arisen in Devonian times, that was certainly abundant in the Carboniferous, and had a few Permian survivors, of which the Gymnarthridae are especially interesting. In general, Microsaurs are not nearly related to the Labyrinthodonts and differ from them in the absence of an otic notch in the skull and in the resulting simplicity of the supratemporal region. They are Lepospondyls and have the notochord invested by bony cylinders.

The Gymnarthridae themselves are an aberrant group that has long been ill defined. Cope described *Pariotichus brachyops* in 1878 from an imperfect skull from the Lower Permian of Texas. E. C. Case described *Gymnarthrus* in 1910 and there has been continued confusion in the identity of this genus itself and in its relationships. *Gymnarthrus* was first thought to be a reptile, then a Stegocephalian, and much of the additional materials collected and studied have contained elements of Captorhinid Cotylosaurs.

Although Case himself did much in later years to help clear up the confusion, the poor state of preservation of much of the material and the small size of the specimens, for Microsaurs are usually but a few inches long, have made elucidation of their relationships difficult.

Within recent years much better material has been obtained from the Permian fissure deposits in quarries near Fort Sill in Oklahoma, and several workers had independently begun revision based on their respective collections. In this volume much of this research has been co-ordinated. The original type specimen of *Pariotichus brachyops* Cope is redescribed and refigured and recognized as a Microsaur, but most of the species referred to this or to supposedly related genera can now be identified as Captorhinomorph reptiles.

The type-specimen of *Gymnarthrus willoughbyi* Case is here regarded as a synonym of *Cardiocephalus sternbergi* Broili, and *Euryodus*, *Goniocara*, *Pantylus* and *Ostodolepis* prove to be related genera, although it is not quite clear at this stage that *Pantylus* and *Ostodolepis* really belong to the family for which the name Gymnarthridae is retained.

These Microsaurs are all small-skulled with short pre-orbital, and long post-orbital, regions. Only *Cardiocephalus* has a parietal foramen. All the above genera, except *Pantylus*, come from the Arroyo formation of the Clear Fork group of the Lower Permian. *Pantylus* has been found in the Clyde and the Putnam formations of the slightly older Wichita group.

Separate sections of the book deal with the auditory region of the Microsaurs and its phylogenetic significance; with Gymnarthrid tooth implantation and succession; and with the postcranial elements.

The authors' conclusions are that the Microsaurs are probably ancestral to the Gymnophionans and are much less closely related to the Nectridia and the Urodela derived from them. The Aistopoda are still more remotely connected. W. E. Swinton

THE IONOSPHERE

The Ionosphere

Its Significance for Geophysics and Radio Communications. By Dr. Karl Rawer. Translated from the German by Ludwig Katz. Pp. 202+10 plates. (London: Crosby Lockwood and Son, Ltd., 1958.) 42*s*. net.

QUITE apart from its vital role as a propagating medium for the radio waves used in long-distance communication, the ionosphere forms an extremely important and fruitful field for geophysical investigation, and, moreover, one in which there is pressing need for further work to be done—work which embraces several branches of physical science. It is surprising, therefore, considering that the world's communication services are largely established by its means, how little attention is yet given to the ionosphere by the average radio engineer.

To the geophysicist as well as to the radio engineer, therefore, the publication of an English translation of Dr. Rawer's original German book on the ionosphere should be welcome, for though there is a vast scientific literature on the subject, there are very few textbooks upon it.

The author first deals with methods by which the ionosphere is 'sounded', including those of radio reflexion, spectroscopic and geomagnetic observation and with a brief mention of the possibilities of rocket flights. The results obtained by these operations are then dealt with in considerable detail, after which the theory of layer formation is discussed, including that of atmospheric ionization by various solar radiations and that of de-ionization by different processes. Chapter 4 discusses the regular changes to which each layer is subject and also describes the different kinds of ionospheric disturbances and other irregular phenomena. An interesting explanation of the special conditions which prevail within the polar circles is given. The final chapter is devoted to the influence of the ionosphere on radio-wave propagation and to methods for predicting the radio conditions in terms of the usable frequency bands. British, Australian and American methods for doing this are described, but the author devotes most space to the method developed by his colleagues and himself, and which is considerably more complicated than the others. Little information is, however, given as to the accuracy of prediction achieved by any of the methods, and one judges, from the final section, that there is room for improvement in this direction.

The book is of a suitable length for a comprehensive introduction to the subject, though much of the material is very condensed. The translated English is not always good, and this, together with the condensed style, tends to render the reasoning, in parts, a little obscure, which may make the book hard going for the student. Against this, however, is the fact that it is profusely illustrated by line drawings and plates, and frequent samples of data in tabular form are presented. An extensive bibliography is given at the end. Undoubtedly, therefore, the book will serve, for many, as a useful introduction to the ionosphere.

T. W. Bennington

BREWING

A Textbook of Brewing

Vol. 2. By Prof. Jean De Clerck. Translated by Kathleen Barton-Wright. Pp. xx+650. (London: Chapman and Hall, Ltd., 1958.) 105*s*. net.

WHEREAS Vol. 1 was predominantly descriptive in the sense of being concerned with various processes as actually managed in maltings and breweries, the present volume is largely complementary in consisting of an account of corresponding laboratory analytical procedures.

This account of practice in a brewing laboratory covers an extraordinarily wide range and there will be few to whom all the numerous estimations are familiar. For example, in addition to dealing exhaustively with the raw materials of brewing and with worts and beers as commonly understood in Britain, the book includes methods relating to vitamin assays, several antiseptics, synthetic sweetening agents and artificial colouring matters which would not normally come into question in Britain. A further valuable feature is a substantial section dealing with the specification of diverse accessory materials such as filtering agents, pitch, detergents, finings, plastics, varnishes, and various fuels and lubricants. Not least important is the concluding part amounting to about 70 pages, which describes the application of such methods to scientific, including microbiological, control in breweries and maltings. The descriptions of the methods themselves are, of course, factually based on published data as indicated by adequate references, while the applications are more in the nature of informal recommendations subject to modification according to the circumstances prevailing in individual establishments.

This book is clearly not intended primarily to establish any scientific principles. For example, to take a single example at random, various empirical estimations of the tannins in hops are adequately described, but the reader must seek elsewhere for evidence that the different results can be interrelated or that they refer to recognizable chemical entities. Other topics, such as the determination of the resistance of beers towards the development of haze, are almost matters of controversy. On the other hand, much of the detail, for example, the colours of light of various wave-lengths (p. 25), and many of the illustrations might seem somewhat tedious or even unnecessary to those whose knowledge is such that they might be turning to this encyclopædic volume. Despite these reflexions, however, this book is the most up-to-date and possibly the most comprehensive handbook and reference work of its kind in existence. Its great virtue lies in describing diverse methods in such detail that, thanks in large measure to the excellence of the translation and general presentation, non-specialists can hope to achieve useful results. Within these limitations it is likely to prove invaluable to those engaged in laboratory work in connexion with brewing. A. H. Cook

Tables of Light-Scattering Functions

Relative Indices of Less than Unity, and Infinity. By R. H. Boll, J. A. Leacock, G. C. Clark and S. W. Churchill. Pp. viii+360. (Ann Arbor, Michigan: University of Michigan Press, 1958. Published for the Engineering Research Institute.) 9·50 dollars; 71*s.* 6*d.*

Tables of Angular Distribution Coefficients for Light-Scattering by Spheres

By Chiao-Min Chu, George C. Clark, and Stuart W. Churchill. Pp. xv+58. (Ann Arbor, Michigan: University of Michigan Press, 1957.) 3 dollars.

THE scattering of light by small particles is of interest in several fields, for example, aerosol physics, atmospheric physics, astronomy, and colloidal chemistry. The fundamental theory rests on Mie's solution of the Maxwell equations for the interaction of a linearly polarized wave and a single spherical particle of diameter D comparable with or larger than the wave-length λ. The solutions are in the form of infinite series of complex mathematical functions, tabulated values of which are still not available for many important conditions.

In the first of these two volumes, values of the scattering coefficient K and the amplitude functions are tabulated for values of the particle refractive index in the range 0·6–0·93, and also infinity, and for 39 values of $\alpha = \pi D/\lambda$ in the range 1–200. These functions are particularly applicable to bubbles of a gas in a liquid or a solid and to the dispersion of a liquid in another of higher refractive index.

In the second publication are tabulated the scattering coefficients and the coefficients of angular distribution of randomly polarized radiation scattered by a sphere for 9 values of refractive index m ranging from 0·9 to 2·0, and also for $m = \infty$, and for values of $\alpha = \pi D/\lambda$ ranging from 1 to 30.

These sets of tables, which are surprisingly expensive, are to be borrowed rather than bought.

B. J. MASON

Vector Spaces and Matrices

By Prof. Robert M. Thrall and Leonard Tornheim. Pp. xii+318. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 54*s.* net.

WITH the exception of the final chapter, the book covers well-worn ground, but does so in an interesting and instructive manner, valuable from the teaching aspect. It builds up the instruction through levels of abstraction, from the concrete to the highly abstract. The reviewer has always held the view that an 'abstract' work on mathematics is unsuitable for the elementary student, especially if, as is so often the case, the work is totally, or almost, lacking in examples. Such students often imagine they understand such a work, but later find out that they did not understand in the least. They should be started on a concrete level, with plenty of examples, but not for too long, and then work up gradually to the heights of abstraction. This procedure the book under review carries out, and it is ably written; most of it is suitable for an honours degree course on the subject-matter.

The chapters, in order, are on: vector spaces, linear transformations and matrices, systems of linear equations, determinants, equivalence relations and canonical forms, functions of vectors, orthogonal and unitary equivalence, structure of polynomial rings, equivalence of matrices over a ring, similarity of matrices, linear inequalities.

The final chapter, containing sections on linear programming, the minimax theorem, and matrix games, is interesting in itself. R. G. COOKE

An Atlas of Airborne Pollen Grains

By H. A. Hyde and K. F. Adams. Pp. xvi+112. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1958.) 36*s.* net.

THIS book is the result of collaboration between a botanist and a medical man engaged in the study of pollen allergy. Its most striking feature is an excellent series of photomicrographs of pollen grains in their natural condition. These have been carefully selected to show the critical features of the grains in both optical section and surface view on a scale of about a thousand diameters. Although many technical terms are necessarily introduced, they are fully explained in the glossary. A well-arranged dichotomous key should make the book a valuable introduction to the study of palynology. Most of the grains illustrated and described are from wind-pollinated flowers, but a number of entomophilous forms are also included.

The book should be a valuable work of reference for the medical palynologist, who will find examples in it representative of all the indigenous pollen types of importance as well as a few exotics, such as *Ambrosia artemisiifolia*, the noxious American ragweed, occasionally found as an adventive in Britain. Apiculturists will also find the book interesting, as many of the anemophilous pollens are utilized by bees as well as the entomophilous forms. The book is admirably produced on glazed paper.

J. HUTCHINSON

Classics of Librarianship

Further Selected Readings in the History of Librarianship. By John L. Thornton. Pp. x+203+8 plates. (London: Library Association 1957.) 24*s.*

THESE further selected readings in the history of librarianship include little of specific interest to the scientist or even to the technical librarian, save that each selection is accompanied by a biographical note on the author. Among the selections of general interest may be mentioned Sir Edward Bond's remarks on public libraries (from his address to the Library Association), H. Bradshaw's presidential address to the Library Association (1882); W. E. A. Axon's "Professorships of Bibliography"; H. R. Tedder on "Librarianship as a Profession"; T. Greenwood on "The Place of Public Libraries in our National Life"; J. C. Dana's presidential address to the American Library Association (1896); T. Mason's paper on Robert Watt, the author of the "Bibliotheca Britannica"; F. Pacy's retrospect of the Library Association at its fiftieth anniversary conference, 1927; W. W. Bishop on the "Backs of Books"; A. Esdaile's "Confessions of a Victorian"; and W. Blade's "The Enemies of Books". As Mr. Thornton admits, the selections are not all major contributions to major literature and are sometimes presented as typical of an author introduced for his contribution to librarianship in ideas or ideals or work. The biographical notes accordingly give the volume an interest and an appeal which may run outside the purely professional field represented by membership of the Library Association. R. BRIGHTMAN

BIOLOGICAL EFFECTS OF RADIATION

At the Second United Nations International Conference on the Peaceful Uses of Atomic Energy only two of the sessions on isotopes and biology were devoted to what might strictly be called radiobiology. Health and safety in the atomic energy industry and advances in the use of isotopes (in biochemistry, physiology, medicine and agriculture) occupied considerably more of the time of the biological sessions. The First International Congress of Radiobiology had been held only one month earlier in Burlington, Vermont, U.S.A., and undoubtedly this Congress, which had been organized long before the Second Geneva Conference was announced, stole much of the radiobiological thunder. Some material was presented in essentially similar form to both meetings and might thus have reached a wider audience : but if the United Nations is to organize a third conference of this sort, a better integration with meetings of international societies is desirable.

It is convenient to think of the biological effects of radiation as falling into two main classes : somatic and genetic. No startlingly new concepts were expounded in the former, but in the relatively small field of genetics one saw the unfolding of a 'new look'. It has long been axiomatic to consider the induction of true point mutations of genes as strictly linearly proportional to the dose of the inducing agent—ionizing radiation—irrespective of the dose-rate of the radiation. W. L. and L. B. Russell (*P*/897) reported results of their many years work on the induction of mutation at seven specific loci in the mouse. The present indications are that the induction of mutations is not linear at all doses and not independent of dose-rate. Further work is necessary to improve the precision of the observations ; for if confirmed, the results indicate that new assessments will be needed of the genetic hazards in a nuclear age.

The fundamentally simple but often tedious approach to the investigation of these genetic hazards is through scoring of point mutations of genes responsible for a single characteristic ; but most of the qualities which constitute 'fitness' of an individual are determined by a multiplicity of genes. The Russells have made a first approach to investigation of fitness by scoring the size of litters and the longevity of offspring sired by an irradiated parent : both show reduction compared with controls. The 'fitness' of irradiated populations has also been investigated by Bonnier *et al.* (*P*/169) and Buzzati-Traverso and Scossiroli (*P*/1391) in the fruit-fly, *Drosophila*. The former found that, when there was strong selection pressure by reducing available food supplies, the adaptation to the effects of irradiation with each generation was quicker : it appeared that the increasing heterozygosity was balancing the induced deleterious effects. The Italian workers also found this increased adaptability of the irradiated population to unfavourable environments. The irradiation induced a variability which permitted a more rapid attainment of conditions of equilibrium. There is no conflict here with the accepted law that the induced mutations are mainly detrimental in themselves, but evidence continues to accrue that the rate of evolution is enhanced even with low doses of radiation (Burdick and Mukai, *P*/895).

Whereas man is certainly the ultimate object of study and the mouse is at present the nearest but *Drosophila* the usual model, invaluable information can be obtained even from bacteria, especially in the elucidation of chemical processes. Haas and Doudney (*P*/896) noted that mutation requires cellular metabolism and that starving the irradiated cell of nutrients diminishes the probability of mutation. Amino-acids and energy-sources are pre-requisites.

Of general interest to geneticists and cytogeneticists was the review by Dubinin (*P*/2074), presented by Prokofeva-Belgovskaya, indicating rapidly increasing activity by Soviet scientists in the fields which are generally regarded as orthodox.

When one turns to consider the somatic effects on the individual, it is found that interest is again directed to the prediction of hazard. Therefore, the relationship of dose to effect is one of the most important functions to determine. When there is but a single exposure to radiation, the objective is readily attained experimentally. For most effects the plot of effect versus dose is sigmoid ; occasionally a linear relationship like the classical response for gene-mutation is obtained. In the latter case there is a tendency to invoke somatic mutation. There has recently, and perhaps especially in the recent report of the United Nations Scientific Committee on the Effects of Atomic Radiation, been a tendency to give more weight to linear relationships than the evidence justifies, for the confirmed examples are very few. Bond *et al.* (*P*/885) now report a further example ; mammary tumours (adeno-fibroma and carcinoma, and fibro-adenoma and sarcoma) increased in Sprague–Dawley rats proportionately to the dose they had received. However, this linearity was obtained only by not scoring beyond ten months. There is a suggestion that the radiation was merely accelerating a natural event. Certainly somatic mutation alone could not be invoked to account for the result, since the manifestation of the tumour was shown to be dependent on humoral influences.

A linear relationship precludes a so-called threshold of dose below which no biological effects can be detected. Without attempting strictly to define the effect–dose relationship, Soviet scientists (Lebedinsky *et al.*, *P*/2068) announced the recording of the effects of very small doses of radiation. By electroencephalography, abnormalities in bio-electrical activity of the cerebral cortex have been seen with doses of the order of 1 r. A similarly sensitive system is claimed for the electroretinogram of the isolated frog's eye.

When one comes to the more difficult problems of interpreting the effects of fractionated doses or of continuous irradiation, the effect–dose relationship may be more complex. Leukæmia, a malignant disease much in the public eye at the moment and not infrequently induced by radiation, has been considered as due to somatic mutation. In mice, however, the results obtained by Mole (*P*/96) in two strains of mice are difficult to fit with this hypothesis, certainly in its simplest form. For

equal accumulated doses the incidence of leukæmia within ten months was anything between 6 and 30 per cent : dose-rate or radiation-free time certainly was a relevant factor. Ford and Mole (*P*/98) also showed elegant pictures of the chromosomal changes found in these leukæmic cells.

Malignant disease apart, a general non-specific shortening of life-span has been attributed to the effects of radiation. It could be postulated that radiation, either as a large single dose or a multiplicity of smaller doses, could act as a non-specific stress to give this result. Curtis and Gebhard (*P*/912) found differences in the patterns of mortality of irradiated and non-specifically stressed mice : in their hands the latter did not cause shortening of life. Following single large doses of radiation to the whole body, the earlier deaths are considered by Maisin *et al.* (*P*/109) to be the sequelæ of irradiation of the lung, the intermediate deaths to irradiation of the head and the latest to irradiation of the abdomen. Lindop and Rotblat (*P*/292) also reported their preliminary results in a very large experiment designed to elucidate some of the problems of ageing. Some of the observed effects were startling, which suggests that confirmation with standard strains of mice is highly desirable.

Malignant tumours and shortening of life result from the administration of radioactive materials giving substantial radiation-doses, the pathological changes being related to the chemical characteristics of the material given and its sites of concentration. The report of Burykina *et al.* (*P*/2077) presented by Krayevsky gives details of the late effects produced by administration of fission products to experimental animals. The title of their communication suggests that the doses were small, which is true in terms of mass, but the tissue-doses were measured in kilorads. Lamerton (*P*/61) reviewed the problems associated with the setting of permissible doses of radioactive materials. He believes that the estimation of the radiation-dose with all its present shortcomings provides the most satisfactory criterion. He argues that for the induction of osteo-sarcoma there is almost certainly a threshold which must be many hundreds of rads. Much of the argument is based on the one comprehensive experiment so far carried out on the long-term toxicological effects of radioactive materials ; some aspects of this work in Chicago relating to strontium-90 were given by Finkel *et al.* (*P*/911).

Whereas radiobiologists are rightly most occupied at the present time with small doses of radiation and delayed effects, there is still considerable interest in the large single dose such as might be received in an accident, or which might have to be incurred by a few to avoid harm to many. Studies have been aimed at conditioning the body to resist radiation-doses normally lethal. This has not led to any practical measure which could safely be applied, but it has led to a better understanding of the effects of radiation on the intact mammal. Hollaender *et al.* (*P*/898) summarized their latest advances in this field of chemical protection. They favour the view that the main function of these agents is neutralization of free radicals formed by ionizing radiation. In the case of other active agents, biological amines, van der Meer *et al.* (*P*/556) argue convincingly in favour of tissue hypoxia. The role of oxygen in affecting the response of cells and tissues to ionizing radiations has been widely studied and Gray *et al.* (*P*/293) reviewed some of their recent work.

In addition to exploring the possibilities of protection against lethal doses, therapy of the animal lethally irradiated has been actively investigated. Hollaender *et al.* (*P*/898) reported their results of administering blood-forming cells which recolonize the marrow spaces of the irradiated animal. This grafting of homologous tissue may lead to undesirable late reactions. Barnes *et al.* (*P*/97), by cytological methods, have noted in some of these homologous chimæras a reversion of the marrow cells back to host type ; apparently the cell clones with the greatest physiological competence, be they of normal donor or radiation-damaged host, ultimately predominate. In both laboratories these therapeutic exercises have involved administration of living cells to the irradiated mouse ; but cell-free chemical agents are still being tried. Soska *et al.* (*P*/2121) claim reduced mortality from irradiation following administration of deoxynucleotides (but not following deoxynucleosides). Similarly, Panjevac *et al.* (*P*/490) found improved survival from the administration of deoxyribonucleic acid or ribonucleic acid from homologous spleen or liver, but not from testis.

Experimental work on the intact mammal has been chiefly the theme of this review. This does not mean that radiobiologists are now getting away from the simple systems—the root of the broad bean, the yeast cell and the bacterium. Many of the papers presented were concerned with the basic lesion in these test objects. Equally there were a number of papers primarily chemical, particularly on the chemistry of the nucleic acids ; and a paper from the U.S.S.R. on effects of radiation on bio-lipids (Tarusov *P*/2248) indicates the continued interest in that country in the effects of radiation in the nervous system.

The collected papers will, of course, be published by the United Nations Organisation as the Proceedings of the Second Conference on the Peaceful Uses of Atomic Energy.

J. F. LOUTIT

PHYSICS OF QUANTA AND PARITY

THE opening session of Section A (Physics) of the British Association meeting in Glasgow on August 28 was devoted to papers presented by members of the Department of Natural Philosophy in the University of Glasgow. The research work of this Department is mainly concerned with studies of photomeson production and photodisintegration, utilizing the high-energy quanta which are provided by the departmental 340-MeV. synchrotron. Three of the papers presented at this session were concerned with experimental investigations of this type ; the fourth, by Prof. J. C. Gunn, professor of theoretical physics at Glasgow, discussed the important discovery during the past year of the non-conservation of parity.

In the opening address, Prof. P. I. Dee traced briefly the development of the concept of quanta from the original suggestion made by Planck, in 1901,

to explain the conflict between the experimental results relating to the distribution of energy in black-body radiation and the straightforward predictions of classical theory in terms of the principle of equi-partition of energy, which had been so fruitful in the development of the kinetic theory of gases. Compton's demonstration in 1923 that the wave-length changes which occur when X-rays are scattered by electrons could be quantitatively explained by treating the problem as a simple collision process, satisfying laws of conservation of energy and momentum, between a quantum of radiation and an electron, showed that the quantum concept applied to much wider fields than those in which absorption or emission of radiation were concerned.

The whole of the physical world, as we know it, may be regarded as comprised of matter and radiation. It is natural, therefore, that the interactions between the elementary quanta of radiation and the basic constituent particles of matter, neutrons and protons, should constitute one of the frontier problems in modern physics. In processes such as these, mesons are created, and in view of the part played by these particles in relation to nuclear forces, experiments of this nature are therefore not only fundamental to the understanding of the basic phenomena of interaction between radiation and matter but also shed light upon the structure of atomic nuclei.

Recent experiments at Glasgow and elsewhere upon the photoproduction of π^+ and π^- mesons in hydrogen and deuterium permit the comparison of the cross-sections for the production of these particles in reactions of quanta with protons and neutrons, respectively. In these experiments the important principle that nuclear forces are independent of charge seems to receive good confirmation. Similar experiments upon the relative production of π^+ mesons in hydrogen and deuterium provide information upon the dependence on spin of the photomeson production interaction. Studies of π^0 production by quanta in helium suggest that in this process the close proximity of other nucleons has little effect upon the primary interactions between the quanta and the elementary nucleons.

The idea of quantization in physics applies, of course, in a much more profound and general manner than merely in relation to the electromagnetic radiation. The concept of structure in the intervening medium was introduced long ago by Faraday to explain the forces between electrical charges. This concept of the 'field' in physics has now assumed a very wide significance. It is even possible that all the elementary particles of matter, the protons, neutrons, mesons, etc., consist essentially of particular quantized states of a general field. Of what this field consists no one at present can say; indeed, it may not yet even be sensible to inquire.

In the following paper, Mr. J. M. Reid (Glasgow) gave an account of recent work upon the disintegration of nuclei under irradiation by high-energy quanta. Experiments of this nature have been made with quanta over a wide range of energies, from a few MeV. up to about 300 MeV. At the lower end of this energy region the main feature in the case of all nuclei is a broad or 'giant' absorption resonance which reaches its maximum at a quantum energy of about 20 MeV. and has a width of about 6 MeV. This resonance has been explained as a collective oscillation in which all the protons in the nucleus move together in one direction while all the neutrons move in the other. Such a picture can only provide a rough indication of nuclear behaviour, since it omits all details of the motion of the proton and neutron 'fluids'. Indications have been found of departures from the bell-shaped resonance curve which such a model predicts. In particular, a cloud-chamber investigation at Glasgow has shown strong absorption of quanta of very sharply defined wave-length at the low-energy end of the 'giant' resonance.

A similar cloud-chamber experiment has confirmed a result obtained in American laboratories by other techniques. This concerns the energy region above the 'giant' resonance where, by virtue of its short wave-length, the quantum energy is so localized that only part of the nucleus is affected. A sub-unit greatly favoured in such interactions has been shown to be a single proton–neutron pair. These two nucleons are, as a result, violently ejected as a free neutron and proton, apparently uninfluenced (at least in a large number of cases) by the presence of the rest of the nucleus. Similarly, when this happens, the rest of the nucleus continues in its state of motion despite the plucking of the pair of particles from within its volume. This seems to open up the possibility of investigating, in a more direct way than hitherto, the nature of the internal motion which is occurring within the atomic nucleus.

Dr. J. G. Rutherglen (Glasgow) delivered a lecture devoted to the techniques and uses of millimicro-second measurements, which have now assumed great importance in atomic and nuclear investigations. For example, the new fundamental particles which have been discovered in the past ten years are all unstable and only live for times between a microsecond and a ten-thousandth of a microsecond. There are many important processes in nuclear physics which take place in comparable, or even shorter, times than this. Measurements of very short time-intervals are therefore necessary to investigate the properties of these particles and processes which are fundamental to our understanding of the basic properties of matter.

The electronic techniques involved in measurements in the region down to a microsecond were developed to a very high degree during the Second World War by the needs of radar and similar applications. At that time the measurements in the field of nuclear physics were limited to about a microsecond by the properties of Geiger counters and similar devices which were then available for the detection of nuclear radiations.

During the past ten years both the detectors and the electronic techniques have been improved in regard to time resolution by a factor of the order of one thousand, so that it is now possible to measure time-intervals as short as one millimicrosecond and to detect even shorter differences in time. The main advance in the detection technique has been the development of the scintillation counter, in which part of the energy of the nuclear radiation is converted into light in a block of transparent material, and the light flash is converted into an electrical pulse by means of a photomultiplier. Techniques of this nature are now commonly employed in many nuclear investigations. For example, π^+ mesons are often identified by measuring the time-interval, of the order of 1/50 microsecond, between the pulse due to the arrival of the π^+ meson and that due to the μ^+ meson which results from its decay. Again, the life-times of short-lived nuclear states may in some

cases be measured in similar fashion, but the order of time resolution which is so far possible is not yet sufficient for very comprehensive investigations in this particular field.

The second main topic at the opening session was "The Non-Conservation of Parity", which was very clearly presented both in respect of its difficult primary concepts and of its fundamental influence upon basic physical principles by Prof. J. C. Gunn. The recent discovery, following a suggestion of Lee and Yang, that parity is not conserved in certain weak elementary particle interactions, represents a revolution in our ideas of space and time in some ways comparable with the introduction by Einstein of his special theory of relativity in 1906. The essence of Einstein's idea was that the laws of all natural phenomena should be the same for all observers in uniform motion relative to each other. It was automatically assumed that along with this invariance of the equations of physics for transitions to moving reference frames would go invariance to reflexions in space and time. In particular, invariance to reflexions in space is mathematically expressed as the conservation of parity. Put in its simplest form, such invariance simply means that the mirror-image of any physical or chemical system shows a behaviour which could occur in accordance with natural laws in the real world. Effectively, the scientist looking at any experiment cannot say whether what he is seeing is the real thing, or a reflexion in a mirror.

It is indeed true that parity conservation, or invariance to reflexion, is observed for all the more ordinary physical processes—the processes controlled by electrical forces, which account for the physics and chemistry of everyday life, and the processes of more recent interest controlled by nuclear interactions. Of course, local conditions, as, for example, biological systems on Earth, may result in only, say, the right-handed form of some molecule or structure occurring, its left-handed mirror-image being absent. However, this is only a local phenomenon and the left-handed variety is, in principle, quite possible.

This is how things rested when Lee and Yang made their proposal that, though invariance to reflexion holds for the strong electromagnetic and nuclear interactions, it might not hold for weak interactions, such as those responsible for β-decay of nuclei and other decay processes of the unstable particles found in high-energy physics. Their hypothesis has been brilliantly confirmed by experiments, both on β-decay and on the decay of unstable particles, and it is now established that parity conservation is violated over the whole range of weak decays. For example, the neutrino emitted in β-decay always spins like a left-handed screw along its direction of motion. The mirror-image of this would be a right-handed screw neutrino and this is not found to exist.

This left-handedness of the neutrino provides a means by which the physicist can now discriminate between a real and a looking-glass world. An important reservation must, however, be made—the mirrored image of a decay experiment with ordinary matter is impossible as a real process for ordinary matter, but, according to current belief, it represents exactly how anti-matter would behave. Thus, if, possibly in other galaxies, there are worlds of anti-matter their neutrinos are right-handed in our sense. In view of the possible existence of such worlds, no universal significance can be expressed to left-handedness. We might indeed say that, like that of biological systems, the handedness of the neutrino is an environmental character, but the environment is a wide one, consisting of all ordinary matter.

MICROWAVE PHYSICS

THE final session of Section A of the British Association meeting in Glasgow was held on September 3, and was devoted to the subject of microwave physics. It was appropriate that the chair should be taken by Dr. B. J. Mason, for he has acted as recorder of this Section for a number of years and now retires from this onerous and responsible position. The meeting warmly expressed their appreciation of his work.

There were three speakers, and it was soon clear that their papers had been planned to try to give, for the non-expert, some indications of the remarkable developments which have occurred in microwave physics since the War. The first speaker, Prof. K. W. H. Stevens, of the University of Nottingham, began his lecture by giving an elementary account of what is meant by electron spin resonance. The magnetic moment associated with the spin of the electron has two equilibrium positions in a magnetic field, of different energies. The moment can be turned from the lower one to the higher one by supplying a quantum of electromagnetic radiation of the right magnitude. For a free electron the relation between the size of the field and the wave-length of the radiation is $H\lambda = 10{\cdot}70$, where H is measured in kilo-oersteds and λ in cm. For fields of order 3×10^3 oersteds, a convenient laboratory magnitude, λ is approximately 3 cm., which is in the microwave region. Very good oscillators and components are available for these wave-lengths, as a result of war-time radar developments.

Although all substances contain many electrons these are usually paired off, with spins opposed. Such pairs do not show electron spin resonance. Thus to demonstrate the resonance it is essential to work with substances containing unpaired electrons, and it seemed, at one time, that this would provide a serious limitation to the use of the spin resonance technique. This has not in fact proved to be the case, for it is now clear that unpaired electrons occur very widely, and one of the great virtues of the technique is that it can investigate these electrons in detail and thus throw light on problems which are of considerable interest and which are not always easily investigated by other means.

This aspect was particularly emphasized in the second part of Prof. Stevens's talk and by Dr. D. J. E. Ingram, of the University of Southampton, who followed him. The main idea is to use the electron magnetic moment as a probe to find out something about the electron motion. In the course of its motion, the electron may move from one atom to

another, in which case there is the possibility that it may interact with the spins of the nuclei around which it moves and thus give rise to resolvable hyperfine structures. Thus, in favourable cases, as the electron explores the various atoms in a molecule or solid, so it gives, by means of the resonance technique, a record of its path. A number of examples were given, and it would seem of value to describe a few of these in some detail. If one takes a mixture of hydrogen peroxide and *iso*propanol and exposes the system to ultra-violet radiation the hydrogen peroxide is broken into two hydroxyl radicals, which are highly reactive and have unpaired spins. They show electron spin resonance. As they now move about in the mixture they attack the *iso*propanol molecules, and transfer their unpaired electrons in exchange for hydrogen atoms, the hydroxyl radical becoming stable water molecules. The free radical formed from the *iso*propanol now shows a resonance which has the typical features expected when an unpaired electron explores six hydrogen atoms. In this way not only is it possible to study how the hydroxyl radicals attack another molecule but it is also possible to learn something about where the transferred electron goes to in the process. Another topical example of a similar nature concerned the existence of free radicals in tobacco smoke. Dr. Ingram reported a preliminary experiment in which he had condensed tobacco smoke at liquid-nitrogen temperatures and had then investigated the condensate. This was found to have a very high concentration of free radicals. The previous example had given an indication of how reactive free radicals are, so it was not surprising to find that he was questioned from the audience about how long such free radicals may exist. This is not known yet, but it could be of the order of seconds. It is thus a sobering thought that every puff of tobacco smoke may transfer to the lungs a large number of very reactive free radicals, and it is clear that this sort of result, though preliminary, may be of considerable importance.

To illustrate the diversity of phenomena which are currently being investigated by this technique, we may mention briefly the following topics which were all described. In semiconductors it is valuable to be able to investigate the properties of minute amounts of impurities, without destroying the samples. These impurities frequently have unpaired electrons associated with them, which can be observed. In coals and oils at about 600° C. it is found that there is a high concentration of unpaired electrons. This may have a bearing on the burning of fuels in internal combustion engines. In polymerization an unpaired electron is found on the end of the polymer and the growth process can be studied. Radiation damage in solids often gives rise to centres which show spin resonance, and the detailed investigation of these, and the comparison with other physical properties, such as colour, are proving of considerable interest.

The third paper was given by Mr. I. M. Ross, of the Services Electronics Research Laboratory at Harlow. His theme was different from that of the previous two speakers, for he chose to discuss the impact which the resonance technique has made on microwaves. A few years ago this could have been a very short paper, for it would be true to say that until very recently the resonance workers have made use of the microwave valves and techniques but have contributed very little in return. However, the recent developments in 'masers', an acronym formed from the initial letters of Microwave Amplification by Stimulated Emission of Radiation, has changed the situation drastically. Two problems which face the microwave engineer are (*a*) how to amplify microwaves and (*b*) how to reduce the noise background in the amplifiers and so increase the sensitivity of the receivers. While masers may not provide the complete answer to his problem they are certainly of considerable promise.

The main idea in a maser is the reverse of that used in a resonance experiment. In resonance use is made of the two spin-levels, and absorption of energy occurs when an electron goes from the lower level to the upper level. If the reverse process occurs, energy is given out. In thermal equilibrium there are always more electrons in the lower state than in the upper state, so that, although radiation may persuade those in the upper states to de-excite, it also persuades those in the lower state to excite, and there is always a net absorption of energy. To get a net emission of energy (for this is what is needed for amplification of microwave signals) it is necessary to have an arrangement whereby one starts with more electrons in the excited state than in the ground state. For continuous amplification this situation must be maintained, but for pulse amplification the emissive state need only be obtained while the pulse is actually being amplified. The problem of getting more electrons (or atoms) into the upper than lower state has caught the imagination of a number of physicists, and a variety of ingenious suggestions have been made and tried.

One of the simplest to understand is that which uses a beam of ammonia molecules, though this does not use the spin energy difference. Ammonia molecules have two closely spaced energy-levels and if one takes a beam of ammonia molecules it is possible to split the beam into two, one containing only molecules in the lower state and the other containing only molecules in the upper state. The molecules in the second beam can then be used to provide energy, by de-exciting them. This system does not lend itself to microwave amplification because of its narrow band-width, but may well provide us with a frequency standard which is more stable than any previously obtained. To increase the band-width and to make amplifiers instead of oscillators it is necessary to go to solids, and then there is no possibility of geometrically separating the excited atoms or molecules, so other methods must be sought. One very ingenious device uses three energy-levels. In this, energy is provided by microwave radiation to promote atoms from the lowest to the uppermost level. Provided that enough power is available it is possible to equalize the populations of these two levels, so that the upper level has gained atoms at the expense of the lowest level. The third, intermediate level, takes no direct part in this, and it is possible to reach a situation in which more atoms are in the uppermost level than are in the intermediate level. A relative population reversal has occurred and emission instead of absorption can be achieved on irradiating the system with microwave radiation corresponding to the energy difference between the middle and upper levels. There are a number of problems involved in actually making a device which works on this principle, as can perhaps be inferred from the fact that one of the most promising maser materials is ruby, which is an impure form of aluminium oxide, containing chromium impurities. The aluminium oxide provides a very good medium in which to have the paramagnetic chromium ions.

A somewhat similar type of amplifier is that which has been known since the days of Lord Rayleigh, and which has recently come into its own in the microwave field. This is the so-called parametric amplifier, and in essence it uses a time-dependent reactance to couple together two resonant systems, in such a way that energy is fed from the reactance variation to the resonant systems. The microwave engineering of this is quite complicated, as was evident from the slide shown, but such devices have been made to operate using either ferrites or garnets as the active material.

In the solids no electron beams are used in obtaining the amplification, and the only sources from which thermal fluctuations can arise are in the devices themselves, in their associated circuitry and from the driving oscillator. The masers have so far only been operated at liquid-helium temperatures (though it is possible that they may be usable at higher temperatures), and have extremely low noise. The parametric amplifiers will work at room temperature, which is a distinct advantage, but they are noisier than the masers, but comparable if not better than any other types of microwave amplifiers.

The immediate applications for which these amplifiers could be very valuable include their use in radio astronomy to detect the microwave radiations from outer space, in communicating with and observing Earth satellites and in increasing the sensitivity of radar systems.

The field of microwave physics which looked a few years ago to be a very specialized and limited one is in fact broadening out in much the same way that nuclear magnetic resonance has developed. Electron spin resonance apparatus is no longer to be found in a few university laboratories, for a number of industries and hospitals have realized its potential value, and there seems every likelihood that its value will be more widely appreciated in the next few years.

In view of this year's theme of the Association, it seemed appropriate to close Section A with an account of the way in which a rather specialized laboratory technique promises to become a powerful tool for industry, and it will be a very good example of the value of pure research to industry if the maser developments have their expected impact on the microwave industry. K. W. H. STEVENS

TRENDS IN METALLURGY

SIR ANDREW McCANCE in opening, on September 1, the session before Section B (Chemistry) of the British Association meeting in Glasgow, dealing with "Some Recent Trends in Metallurgy", reviewed in broad outline the progress made in the scientific world during the past few years and emphasized the important part that metallurgy had played in making this possible. He said the standard of living of industrial countries was indicated very largely by the steel consumption per head of population. By this standard the United States led the world with Germany and Britain 20 per cent and Japan 85 per cent below the American standard. British production per man employed had increased by 55 per cent since the War. This truly remarkable achievement had been brought about by an increase in the size of the producing unit, by improved equipment and by advances in technical knowledge such as the use of oxygen in steel-making.

The impact on metallurgical practice of the ever-increasing demand for materials to withstand higher temperatures and pressures had been very marked and he felt that the difficulty of finding metals of such strength to withstand working temperatures of 800–900° C. would cause a definite hold-up in progress. Though it was dangerous to argue from analogy, and we had only the most elementary guide to a pathway through the wilderness of ignorance, it was not out of place to point out that the most successful high-temperature alloy to-day was based on nickel with a melting point of 1,450° C. and chromium with a melting point of 1,850° C. The science of metals had lagged behind the technology of their use, and more imaginative work on factors contributing to their strength properties was a field offering great practical possibilities.

Creep and brittle fracture were two interesting problems of a fundamental nature, and though they had given rise to innumerable papers and much discussion yet remained in about the same state of advancement as they were ten years ago. In the case of brittleness it would appear that the results depended just as much on the type of test as on the nature and condition of the material being tested. A completely new approach to this problem would be welcome.

In the science of metals progress had resulted from the work of physicists rather than of metallurgists, and the fascinating developments in the use of semiconductors like germanium and silicon and the immediate applications to which inventions based on these discoveries had been put are outstanding achievements. However, during the past ten years much had been written about dislocations and they had been brought into the explanation of every conceivable property that metals possess. Sir Andrew regretted, however, that in many of these explanations there was more mathematics than physics and thought it doubtful if any real quantitative contribution had been made to our knowledge of the properties of metals by the dislocation theory, although it had contributed to our qualitative understanding of why metals behave as they do.

In a discussion of some recent applications of chemistry to metallurgy, Prof. R. Hay and Dr. P. T. Carter described the development of the modern highly mechanized iron blast furnace. Most of this development had resulted from the efforts of the engineer, but more recently, the metallurgist, using a chemical approach, had made important contributions. Investigations into the rate of reduction of different ores had led to the use of properly sized burdens, and petrological studies of the changes occurring during sintering into lump form of the fines produced during crushing, or blown out of the top of the furnace, had shown that the formation of fayalite (Fe_2SiO_4) caused a serious decrease in reducibility. Later work showed that fayalite formation could be avoided if the iron oxide particles could be bonded together by diffusion in the solid state, without melting occurring.

When melting could not be prevented, fayalite formation could be avoided by adding lime to form calcium silicate. In smelting lean ores, the incorporation of lime in the sinter mix ensured at the same time intimate mixing of the gangue and flux, and easy reducibility of the iron oxide, and now all the ore can be converted into easily reducible sinter, with a reduction of about 30 per cent in coke requirements.

Recent research into the constitution and properties of blast furnace slags was also described. A knowledge of their viscosities and melting points, and of their ability to control impurities in the iron such as sulphur and silicon, had contributed considerably to improved blast furnace practice in recent years.

The important effect of impurities on metal properties was described, and methods for their removal were discussed. Selective oxidation of impurities was well known, and recent compilations of thermodynamic data on metal/oxide systems allowed quantitative assessment of such methods. Selective chlorination could also be used, as in the removal of zinc from lead, and it was suggested that recent improvements in fluorine technology might result in similar applications for fluorine.

These methods introduce elements which may be as harmful as the original impurities. After selective oxidation, suitable deoxidizers—the choice being determined by cost, solubility and the formation of easily removable products—could be used, but the metal still contained small amounts of deoxidizing elements. The nearest approaches to the production of pure metal had been obtained by complicated and protracted chemical methods, or the comparatively simple zone-melting techniques developed by Pfann. Remarkable degrees of purification were possible, and in the case of germanium, impurities which affected its electrical properties could be reduced to less than one atom in 10^{10}. Similar degrees of refining were possible with gallium and antimony, and most of the impurities could not be detected even by spectroscopic methods. Problems of contamination from the container used in the zone refining of reactive high melting point metals such as silicon, iron, germanium, etc., had been overcome by the use of floating zone techniques, in which no container was used, the molten metal being held in place by its own surface tension. Iron prepared thus showed ductility even at temperatures approaching 0° K.

Gaseous impurities were more difficult to remove, but recently, induction vacuum melting and consumable electrode vacuum arc melting had been successfully applied to the production of large ingots. The former had been used particularly for the nimonic type of alloys, since it afforded close control of composition, and for certain special steels, and ingots up to 2,000 lb. had been made by this process. Consumable electrode processes in which air-melted electrodes were consumably remelted in water-cooled copper crucibles were now an integral step in the production of titanium, zirconium, molybdenum and many special alloy steels. They were less costly than vacuum induction melting, and could make ingots up to six tons.

Both processes were costly for the large tonnages usually encountered in steel-making, but vacuum degassing in the mould, which was cheaper and simpler, had resulted in considerable reduction in the hydrogen, nitrogen and oxygen contents of steel.

The newer metals in industry were discussed in a paper presented by Dr. H. M. Finniston and Dr. P. Murray. They pointed out that the newer metals fell into two groups. The first had a specific purpose for which it was difficult to see applications outside the field for which they were originally developed. To this group belonged uranium, thorium and plutonium, with perhaps germanium and silicon. The second group, which included titanium, zirconium, beryllium, niobium and molybdenum, was likely to have a wider field of application. For example, zirconium has very good corrosion resistance and niobium has potentialities as a high-temperature creep-resistant material.

There were, however, several similarities between these metals. The extraction processes, because of the stability of their oxides, were all relatively complicated. All these metals were reactive and in many cases their physical properties, especially ductility, were adversely affected by small concentrations of gaseous impurities such as hydrogen, oxygen and nitrogen. This had led to developments in vacuum melting and casting techniques. In the case of the very high melting point metals thorium and niobium, powder metallurgy techniques had been employed with advancement in the use of high-pressure and high-temperature vacuum-sintering operations. The physical metallurgy of some of these metals was complicated due to the number of phase changes and to their alloying behaviour not conforming to the pattern of the more common metals.

In discussing the first group of metals the authors pointed out that the most interesting and important feature of uranium was its behaviour as a fuel in a reactor when bombarded with neutrons and this had introduced a completely new problem in metallurgical studies. At temperatures up to 350° C., growth occurred due to change in crystal shape, and at temperatures higher than 350° C. swelling of the metal took place. The former—generally referred to as 'wrinkling'—occurred in material with a marked texture and could be overcome by obtaining a randomly oriented fine-grained structure prior to irradiation. The latter effect was due to the nucleation of bubbles of the inert gases, krypton and xenon, produced by fission. This was accompanied by a marked decrease in density of the metal.

Plutonium, the synthetically produced metal from the uranium in the reactor, was metallurgically unique in that it existed in six different phases between room temperature and its melting point (630° C.). Two of these phases exhibited negative coefficients of thermal expansion.

Of the second group of metals titanium was the most extensively used, largely as a structural material in alloy form in the aircraft industry. In the range 200–400° C. titanium alloys possessed a better strength/weight ratio than either of its competitors, aluminium alloys and alloy steels. Above 400° C. alloy steels were superior. Zirconium, although a high melting point metal, was also disappointing in that at medium temperatures its strength, like that of titanium, was not very good. All the early zirconium metal contained small quantities of hafnium, but although this metal is an identical twin of zirconium in chemical behaviour, in the nuclear reactor there is no such similarity. Though zirconium was virtually transparent to neutrons, hafnium absorbed so many that it is considered a most suitable material of construction for reactor control rods. Zirconium is primarily a sheathing material in pressurized water reactors where good corrosion resistance in water at temperatures up to 325° C. is essential. Zirconium alloys have been developed with corrosion-rates as low as 1/5,000 in. per annum.

Knowledge of beryllium and its properties has advanced considerably over the past ten years largely as the result of its potential applications in nuclear reactors. It has been used for many years as an alloying element particularly with copper. The metal is extracted by two methods. The principal method is the thermal reduction process using magnesium reduction of beryllium fluoride at temperatures above the melting point of beryllium. The metal forms as globules which float to the surface of the bath. For removal of magnesium fluoride, melting *in vacuo* or under partial pressure of argon is employed. The other method of production uses the electrolysis of fused salts, mostly the eutectic mixture of sodium and beryllium chlorides, although fused fluorides have been used. Beryllium can be extruded over the temperature-range 400° C.–1,000° C. Sheathing of the metal provides a solution to the health hazard, iron being the usual sheathing metal. A technique using the combined operations of powder metallurgy, consolidation and extrusion has been successfully developed. Beryllium is associated with inherent brittleness due to cleavage occurring along the basal plane. Attempts have been made to produce very pure beryllium. Zone refining has given disappointing results; but evaporation of vacuum-melted high-purity electrolytic flakes has yielded a very pure metal having an oxygen content of 10 parts per 10^6. Such small crystals as were tested fractured in the normal fashion. Above 400° C. the mode of failure changes from transcrystalline to intercrystalline; but the reasons for this change are unknown. In spite of such difficulties the metallurgist has succeeded in developing a wide variety of fabrication techniques and has also succeeded in joining beryllium to other metals and to itself.

Several methods have been proposed for the production of niobium such as electrolysis of fused potassium niobium oxyfluoride, the reduction of the oxide by the carbide and the reduction of potassium niobium fluoride by sodium or magnesium. The main method of consolidation is sintering of cold-pressed compacts. Niobium metal is an excellent 'getter' absorbing both oxygen and nitrogen rapidly on heating. Hydrogen is also absorbed at temperatures up to 500° C. The elimination of non-metallic elements is essential for the production of ductile metal. The three main methods of purification which can be utilized during sintering are: (1) low-temperature eliminations of hydrogen up to 1,100° C.; (2) the formation of carbon monoxide above 1,650° C.; (3) the elimination of oxygen probably by volatilization of an oxide of niobium at temperatures above 1,900° C.

An important factor in attaining sound bars is the correct grading of the powder. Too fine powder sinters too quickly at the surface, resulting in retention of the gases and ultimate formation of gross internal voids. The sintered bar is cold forged and re-sintered at a maximum temperature of 2,300° C. The resulting pure metal is ductile and can be formed cold by most of the usual methods. Hot forming is not possible owing to the pick-up of gases resulting in embrittlement. At present its only industrial use is in nuclear reactors as a canning material. If alloy development succeeds in realizing the potentialities of niobium as a high-temperature creep-resistant material and can overcome its poor oxidation resistance the field of possible application will be widened considerably.

In the final paper Dr. N. P. Inglis and Mr. J. B. Cotton discussed the corrosion behaviour of tantalum, niobium, titanium, zirconium and beryllium. All these elements readily form oxides, and this in part is a factor in their very resistant behaviour under a wide range of conditions. The oxide film can prevent further attack provided this film is very closely bonded to the metal. Investigations of the attack of various solutions ranging from hot fuming sulphuric acid through hot neutral salt solutions to hot strong sodium hydroxide solutions on these metals had shown that tantalum was the most resistant, being closely followed by niobium, while beryllium was attacked by all the corrosive media. Titanium had good resistance to neutral chlorides and it was estimated that titanium sheet of the thickness of a postage stamp would take four thousand years to disappear in sea water. Titanium, though not nearly so resistant to attack as tantalum, was much cheaper and showed fair resistance to non-oxidizing acids. This suggested further examination of the possibility of forming protective films to raise its resistance to that of tantalum, and it was shown that the growth of oxide films could be stimulated by slightly raising the oxide potential of the metal when in contact with the corroding medium. The method of raising the potential was not important, provided its value exceeded a certain critical value. Titanium could be protected by connecting it to a more noble metal such as platinum or carbon. This was shown with the aid of cine-film in which the behaviour of a piece of titanium without protection was compared with that of another piece to which a protective potential was applied. Another example of protection was shown in which titanium with an extremely thin surface-film of platinum and another piece without such protection were immersed in a current of sea water.

R. HAY

A NOVEL TYPE OF METAL-PROTEIN COMPOUNDS

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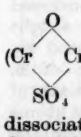
ALL proteins are capable of binding metal ions, but the extent of binding and the stability of the metal-protein compounds vary greatly both with the nature of the metal ion, the nature of the protein and its net charge[1]. The transition group elements possess the greatest affinity for proteins generally and form the most stable compounds[1]. Positively charged polynuclear chromium complexes, such as



$(Cr \quad Cr)^{3+}$, are held very firmly, so that no dissociation of the metal-protein complexes is detectable. The co-ordinate bond formed is largely covalent. The chromium complexes are potent

cross-linking agents, stabilizing the protein. Thus, collagen binds basic chromium sulphate tenaciously; a reaction utilized in the important process of chrome tanning of leather. The chromed hide resists the action of boiling water and proteolytic enzymes. It is now generally considered[2] that in the initial reaction the cationic chromium complexes discharge the carboxylic ions of the protein. The electro-neutralization of the charges of the components of the system is followed by penetration of the carboxyl groups into the chromium complex, which results in the formation of co-ordinate-covalent bonds of great stability between the carboxyls and the chromium atoms of the complex.

Chromium-collagen compounds. Chromium is an exceedingly versatile metal so far as the formation of complexes goes. In aqueous solution of basic sulphates, polynuclear complexes with positive and negative electric charge as well as uncharged ones may be present simultaneously. The degree of affinity of the ligands for the chromium atom governs the nature of the complexes formed. Apart from the common type of cationic chromium-carboxyl compounds, other combinations are known, such as compounds with anionic chromium complexes attached to the ε-amino groups of the lysine residues and the guanidyl group of the arginine residue. These chromium-collagen complexes do not attain the exceptional stability possessed by the normal carboxylate type. Furthermore, it has been suggested that the hydroxy group of the hydroxyproline residue participates in the binding of non-ionic sulphito-sulphato-chromiates by collagen[2]. The present article outlines the reaction of neutral chromium complexes present in extremely basic chromium perchlorates with collagen. This reaction leads to the formation of an entirely new type of metal-protein complexes in which the uncharged chromium complexes are attached to the protein through its non-ionic keto-imide groups. Judging by the stabilization obtained by the fixation of these chromium perchlorate complexes, they cross-link the protein units. This novel class of metal-protein compounds should appear to be of general chemical interest, particularly from the points of view of the behaviour of proteins and complex chemistry.

The basic chromium perchlorates corresponding to the empirical formula: $Cr_3(OH)_{6-n}(ClO_4)_n$, where $n \geqslant 4$, their composition designated as per cent acidity $\left(\frac{n}{6} \times 100\right)$ in the following, contain in dilute and moderately concentrated solutions only positively charged complexes, free from ClO_4^- groups. By increasing the number of hydroxyl groups, stable aqueous solutions are obtained, containing compounds of the type $Cr_3(OH)_{6-n}(ClO_4)_n$, with $n \ll 2$. Most of these complexes do not migrate on free electrophoresis and do not react with ion exchangers. Thus, solutions of the 33 per cent acid perchlorate contained about 65–70 per cent of uncharged complexes and 30–35 per cent of cationic ones. The composition of the complexes first mentioned corresponds to the formula $(Cr_3(OH)_6ClO_4)_m$, and of those last mentioned to $Cr_3(OH)_8(ClO_4)_4$. The average molecular weight of the 33 per cent acid perchlorate, estimated by measurement of diffusion, indicates values of m equal to 2 or 3. The purely cationic complexes of the 67 per cent acid salt contain two chromium atoms on the average[3]. These react with collagen in the usual way, attaching themselves to the charged carboxyl groups of the protein. The neutral chromium complexes of the extremely basic perchlorates show an entirely different type of reaction with collagen. A résumé of some results obtained on investigating the mechanism of their fixation by hide protein follows. Detailed accounts of these researches will be given elsewhere.

Table 1

No.	Substrate	67 per cent acid chromium-perchlorate (m.equiv. chromium fixed by 1 gm. collagen)	33 per cent acid chromium-perchlorate: m.equiv. chromium fixed by 1 gm. collagen	33 per cent acid chromium-perchlorate: (Per cent acidity of chromium-collagen-compound)
1	Hide powder (H.P.)	2·1	4·4	27
2	Heat-denatured H.P.	2·2	7·9	20
3	Esterified H.P.	0·3	2·7	—
4	Deaminated H.P.	1·8	4·9	25
5	N-acetylated H.P.	2·0	4·2	—
6	N- and O-acetylated H.P.	1·9	5·6	—
7	H.P. pretreated in 2 *M* $NaClO_4$ solution for 7 days	2·4	9·1	18
8	H.P. tanned with tannic acid; 92 per cent tannin fixed by collagen	1·5	0·3	—
9	Polyamide	0·1	3·4	17

The solutions of the extremely basic chromium perchlorates, 33 per cent acid or less, were prepared by addition of sodium hydroxide, in 10 per cent solution, to a solution of the 67 per cent acid perchlorate, which in its turn was obtained by boiling freshly precipitated hydrous chromic oxide (from hexaquochromium chloride) with the required amount of perchloric acid. The final solutions, containing 1·00 equiv. chromium per litre, were at least six weeks old when used. The *p*H values were 3·4 and 2·9, respectively.

The complex composition of these solutions of the 33 and 67 per cent acid chromium perchlorates was ascertained by the ion exchange method[3], employing the sodium salt of 'Dowex-50' and the perchloric acid salt of 'Amberlite IRA-400'. The 33 per cent acid compound contained 72 per cent uncharged complexes of 17 per cent acidity, the rest being cationic. The 67 per cent acid chromium perchlorate contained positively charged complexes only.

Reaction with collagen and modified collagens. In Table 1, results on the irreversible fixation of these two chromium perchlorates by specimens of intact collagen and various modified collagens are given. In these experiments, portions of the substrate equal to 1·0 gm. of collagen were made to react with 25·0 ml. of the solutions of the chromium perchlorates for 120 hr. The degree of chromium fixation is stated in m.equiv. chromium bound by 1 gm. of the protein. The preparation and properties of the specimens of modified collagen were described in a recent monograph[4].

The results in Table 1 indicate the following facts. By increasing the number of co-ordination sites on the collagen, that is, uncompensated —CO·NH— links, by heat shrinkage (No. 2) and by pretreatment of the hide powder with concentrated solutions of lyotropic agents (No. 7), the fixation of the chromium complexes in the form of neutral compounds is practically doubled, while the fixation of cationic chromium complexes of the 67 per cent acid chromium perchlorate is only slightly affected. This indicates the dominance of the keto-imide groups of collagen in the fixation of uncharged chromium complexes. By the

inactivation of the carboxyl groups by methylation (No. 3), the binding of the cationic chromium complexes is practically eliminated, whereas the uncharged complexes of the extremely basic perchlorate still show marked affinity for the modified collagen, the amount of chromium fixed being about 60 per cent of that of intact collagen. By complete acetylation of the ε-amino groups, or by their diazotization, the reactivity of collagen towards the chromium perchlorates is changed very little. In the case of the exhaustively acetylated specimen, with all the ε-amino groups and the major part of the hydroxy groups affected, the fixation of the extremely basic perchlorate is favoured, while that of the cationic chromium complexes is slightly lowered. The markedly increased reactivity of the completely acetylated collagen with the non-ionic chromium complexes is probably due to the freeing of some of the —CO·NH— links from the hydroxy groups of the hydroxyproline residue, making additional sites available for hydrogen-bonding[5].

In specimen No. 8, with practically complete blocking of the —CO·NH— links and a partial inhibition of the reactivity of the ionic protein groups, the uptake of uncharged chromium complexes is practically prevented, while the cationic chromium complexes still show great affinity for the tanned collagen. The lowered fixation is, in the latter instance, probably to be accounted for by the impaired reactivity of the ionic groups of collagen resulting from its binding of tannic acid[2]. All these findings are in harmony with the supposition that the uncharged (non-ionic) chromium complexes of the 33 per cent acid perchlorate are reacting with and attached to the keto-imide groups of collagen. Final proof is provided by the large fixation of the chromium complexes by the modified polyamide, which fixes about 75 per cent of the amount of chromium bound by intact collagen from the 33 per cent acid chromium perchlorate. The polyamide is inert to cationic chromium complexes which require ionic carboxyl groups for their fixation. Its reactivity is limited to the —CO·NH— link.

Hydrothermal stability. As a measure of the degree of effectiveness of the two types of chromium complexes in stabilizing collagen, the determination of the temperature of shrinkage, T_s, is a simple but very informative indicator. Specimens of isoelectric calf-skin, which had been tanned with the 33 per cent acid chromium perchlorate to contain 3·1 m.equiv. chromium per gm. of collagen, commenced to shrink in water of 84–86° C. Specimens which had been tanned with the 67 per cent acid chromium perchlorate to contain 2·0 m.equiv. chromium per gm. of collagen shrunk at 92–94° C. It should be noted that by the binding of about 2 m.equiv. chromium per gm. of collagen in the form of cationic sulphatochromium complexes, complete resistance of the chromed collagen to boiling water is obtained ($T_s >$ 100° C.). In this connexion, it is of interest and of some significance to note that by fixation of vegetable tannins, that is, polyphenols which are hydrogen-bonded to the keto-imide groups at several points, the shrinkage temperature of skin collagen is increased to 80–90° C. by the most effective tannins[2]. The degree of stabilization of collagen obtained in the two processes, the vegetable and this non-ionic mineral tannage, involving mainly —CO·NH— links, is evidently of the same order of magnitude.

Reaction with gelatin solution. Gelatin is the classical reagent for vegetable tannins, already studied by Davy[6]. In slightly acid solution (*p*H 3–4), gelatin forms a copious precipitate with solutions of tannins. Since urea-formaldehyde condensation products, which contain the —CO·NH— link as the chief functional group, are equally effective precipitation agents for vegetable tannins as gelatin[7], the reaction is generally believed to be an attachment at several points of the polyphenol to the —CO·NH— links of adjacent gelatin molecules, resulting in the formation of insoluble aggregates[8]. Cationic chromium complexes do not show this reaction. However, by adding a solution of the 33 per cent acid perchlorate to the gelatin solution, a bulky precipitate was formed. It was filtered off immediately, washed and analysed for chromium, perchlorate and protein (nitrogen × 5·56). The filtrate was also analysed. The results are given in Table 2.

Table 2. Precipitation of Gelatin Solution by Solution of 33 per cent Acid Chromium-Perchlorate

Reaction balance :	Chromium (m.equiv.)	Perchlorate (m.equiv.)	Per cent acidity
Original solution	10·00	3·30	33
Residual solution	4·10	2·24	55
Fixed by the gelatin	5·90	1·06	18
Fixed by 1 gm. of protein	*14·8*	*2·65*	*18*

The following technique was used. To a portion of 40·0 ml. of 1·0 per cent gelatin solution (400 mgm. of protein), a quantity of 10·0 ml. of the 33 per cent acid chromium perchlorate, 1·00 equiv. chromium per litre, diluted with 30·0 ml. of water, was gradually added with constant shaking. The gelatin used in the series of Table 2 was a normal type of alkali-processed calf-skin gelatin, with its isoelectric point at *p*H 5·0.

By direct analysis, it was found that the chromed gelatin contained 21·8 per cent chromium sesquioxide, 58·9 per cent protein and 15·0 per cent perchlorate. The per cent acidity of the fixed chromium salt was 17. 14·6 m.equiv. chromium was fixed per gm. of protein.

The keto-imide link as the binding site. The fixation of vegetable tannins by the polyamide proves that the —CO·NH— link is its main reacting centre. Since the hydrogen atom of the phenolic group is the donor in the hydrogen-bond formed with the keto-imide group, its oxygen atom should be the acceptor. That the hydrogen atom of the —CO·NH— link is not necessary for the reaction is proved by the fact that structures containing the —CO·N= group alone, corresponding to the link formed by condensation of the prolines in the collagen chains, possess marked affinity for polyphenols of the vegetable tannin type. Polyvinylpyrrolidone is such a model substance[9]. A precipitate was also formed when a 2 per cent aqueous solution of polyvinylpyrrolidone was gradually added to a solution of chromium perchlorates with per cent acidities less than 33. This test is an additional indication that the complex formation with the non-ionic chromium is localized to the oxygen atom of the keto-imide group. However, gelatin is by far the most efficient precipitating agent for the uncharged chromium complexes, which might be due to the participation of auxiliary groups of the protein, lacking in the polyamide and polyvinylpyrrolidone.

By the fixation of cationic chromium complexes by collagen, its isoelectric point is shifted towards higher *p*H values, or from pH_I 5 to pH_I 7–7·5[2], due to the partial inactivation of carboxyl ions of the zwitter-

ionic protein. Applying the dye-technique, the pH_I was found to be 5·5 for the chrome-collagen compounds obtained by tanning with the extremely basic perchlorates of chromium. Thus, no appreciable displacement of the original isoelectric point of the collagen occurred due to the non-ionic chrome fixation. The binding of chromium by the non-ionic protein groups should not be expected to affect the location of the pH_I.

The results of the present investigations suggest that the keto-imide group of collagen is responsible for the irreversible binding of the nonionic chromium complex of extremely basic perchlorates of chromium. No definite information on the nature of the valency forces involved in the attachment of the chromium complexes to the —CO·NH— link at several points has as yet been obtained, whether the binding takes place by co-ordination of the oxygen atom of the keto-group on the chromium complexes, the formation of some type of hydrogen bond, or by ionization of the —NH— link, or by a combination of such reactions. Rabin[10] and Murphy and Martell[11] have presented evidence that peptide oxygen rather than peptide nitrogen is involved in the reversible interaction of some metal ions with simple peptides. The findings of improved hydrothermal stability and the changed reactivity of the chromed collagen, as well as the ability of the non-ionic chromium complexes to precipitate gelatin are satisfactorily explained by a reaction involving co-ordination of the chromium atoms on the oxygen atom of the keto-group of the keto-imide link. The main feature, which is firmly established, is that the compounds formed represent a novel type of metal-protein compounds which may be of value for the location of uncompensated keto-imide links in proteins, for example, by modern optical methods.

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OBITUARIES

Mr. R. W. Sloley

The news of the death of Mr. R. W. Sloley, of Amersham, Bucks, on August 19 at the age of seventy-nine, has been received with sorrow by a large circle of friends and scholars. He took his degree at St. John's College, Cambridge, and he never lost contact with his University. After graduating, he joined the staff of Liverpool College, but during the First World War he went to the Department of Instrument Inspection of the Air Ministry, where he remained for the rest of his professional career. He speedily made his mark in this Department, and during the War spent some time stationed in France. When peace came, he continued his work at the Air Ministry depot at Kidbrooke, and during his service there he wrote a book on aircraft instruments which ran into several editions and is still in use.

At first he lived at Blackheath, but in the later 1920's he migrated to Amersham, where, while continuing to serve at Kidbrooke, he settled down for the rest of his life in company with his father and his sister, for he never married. Both these relatives died before him, and during the last years of his life he lived alone except for his books and his many friends, to whom he frequently extended hospitality. Early in 1939 he retired from the Air Ministry, and thereafter devoted himself to his many hobbies.

Sloley was a widely travelled man, and in his earlier years had visited South Africa and India, for he had connexions with both countries. His interests outside his regular work included music and the arts (he became vice-president of the Chiltern Arts Club during his residence in Amersham); also science, general archæology and Egyptology. In this last subject he was particularly interested; he studied the Ancient Egyptian language for a year or two at University College, London, but his real interest was in Egyptian mathematics and science, and more particularly in Egyptian astronomy and methods of measuring time, on which topics he was probably better informed than any English professional Egyptologist. In November 1930 he delivered to the Egypt Exploration Society an admirable lecture on primitive methods of measuring time which was afterwards published in Vol. 17 of *The Journal of Egyptian Archæology*, and in 1942 he contributed the chapter on science to the volume, "The Legacy of Egypt", edited by the late Prof. S. R. K. Glanville. He also served for some years on the committee of the Egypt Exploration Society. He did a great deal of lecturing to schools and societies, and once in the days of 2LO broadcast a talk on "A Day in the Life of an Egyptian Schoolboy". His last contribution to Egyptian archæology was a brief note in Vol. 39 of the *Journal of Egyptian Archæology* on radio-carbon dating as applied to Egyptian antiquities. His interest in ancient science, however, was not confined to Egypt, but extended also to Babylonia, and even perhaps to India. Under his quiet manner lay an unusually wide culture, and he will be greatly missed by all who knew him. R. O. Faulkner

Prof. George Fegler

After a distinguished career in medical and biological research, George Fegler died in Cambridge on September 23 at the age of fifty-nine. In Poland, between the time that he received his medical degree (Warsaw, 1924) and the outbreak of the Second World War, he held a number of important research and teaching posts, and in 1939 had just been elected to the chair of physiology at Vilna when he was recalled to the Army. Afterwards he worked in Edinburgh, where, during 1941–46, he was professor of physiology in the Polish Medical School and took part in the war research programme of the University

Department of Physiology. In 1950 he was appointed principal scientific officer at the Agricultural Research Council Institute of Animal Physiology, at Babraham, a post which he held until his death.

His thirty-four years of research covered an unusually wide range of problems; but his greatest interest was in respiratory and cardiovascular physiology, and it was in connexion with problems in these fields that he had recently developed his thermodilution method for the measurement of blood-flow. The method is similar in principle to other indicator–dilution methods, notably the dye–dilution technique, but for certain purposes has a number of advantages over that method. Fegler himself used it successfully to determine cardiac output, renal and portal flow in the dog and sheep; other laboratories had shown considerable interest in the method and had requested his assistance in modifying it for other uses, notably as an aid to clinical investigation.

The method, while favourably received by some, was criticized by others, chiefly on theoretical grounds. Fegler met criticism by testing experimentally each point that had been raised, and extending his controls so that he could assert with confidence that the method fell within the same limits of error as other accepted methods. He also presented a reasoned analysis of the thermodilution curves which showed that perhaps his critics rather than he had strayed into error. But he took no pleasure in polemics. He examined all criticism carefully so as to be sure he had a reliable tool for the research which he had planned. Some progress in this work, a study of the normal shifts in blood-flow from different organs in relation to the metabolic demands of the body, had already been made by him. It is typical, however, that he was at the same time attempting to improve his methods, so that he could, on one hand, achieve more nearly physiological conditions of experiment, and on the other, come closer to that impossible goal of physiologists, an ideal method of measuring blood-flow.

To his colleagues, with whom he discussed these and other problems and who have in the past benefited so much from his experience and scientific knowledge, his loss is a very real one. CATHERINE O. HEBB

Mr. C. C. Mason, O.B.E.

MR. CECIL CHARLES MASON died suddenly on September 9 at the age of seventy-seven.

Mr. Mason graduated with a first in the Mathematical Tripos at Cambridge, and joined the Cambridge Instrument Co. in 1910. He was a joint managing director from that year until his retirement from executive work in 1941, and he remained on the Board until his death. Appointed O.B.E. for his work on shell fuses in the First World War, Mr. Mason was not only responsible for many other technical advances in the instrument field, but also made major contributions to the Company's growth through his wise administration and financial acumen.

Mr. Mason was respected by everyone, and his loss will be keenly felt by a host of friends.

NEWS and VIEWS

Atomic Energy Research Establishment, Winfrith Heath: Mr. D. W. Fry

IN 1956 the Atomic Energy Authority decided to build a new establishment of its Research Group. A site was chosen at Winfrith Heath in Dorset, and, after a public inquiry, the Authority was given permission to use it in 1957. Work is advancing rapidly on this new establishment, and the Authority has announced the appointment of Mr. D. W. Fry as the person responsible to the director of the Research Group for its development and the initiation of the programme.

Donald William Fry, who was born at Weymouth in 1910, was educated at Weymouth Grammar School and King's College, London. He worked in the General Electric Company's research laboratories for four years before moving to the Royal Aircraft Establishment, Farnborough, in 1936. There he took part in the development of very high-frequency communication equipment for R.A.F. Fighter Command. During 1940–45 he served in the Telecommunications Research Establishment on the development of microwave radar. Fry, and several of his colleagues, joined the staff of the Atomic Energy Research Establishment in 1946. This group, working in Malvern, demonstrated the practicability of the high-current linear accelerator and the electron synchrotron. Fry was awarded the Duddell Medal of the Physical Society in 1950. He became head of the General Physics Division at Harwell in 1950. The main work of the Division has been in the high-energy accelerator and thermonuclear fields. Fry was appointed chief physicist of the Atomic Energy Research Establishment in August 1954 and promoted to be a deputy director of the Establishment in February 1958.

Atomic Energy Research Establishment, Harwell

THE following staff changes at the Atomic Energy Research Establishment, Harwell, are announced by the United Kingdom Atomic Energy Authority:

Dr. J. V. Dunworth, formerly head of the Reactor Division, has been appointed assistant director (reactor research policy). In this post he will be special adviser to the director of Harwell. He is succeeded as head of the Reactor Division by Mr. T. M. Fry, who has been a deputy head of the Reactor Division.

Dr. Peter Thonemann, head of the Controlled Thermonuclear Reaction (Fusion) Division at Harwell, has been granted study leave for one year from March 1959. He will be going to the Institute of Advanced Studies in the University of Princeton, where he will work on plasma physics. In Dr. Thonemann's absence the Harwell fusion programme will be carried forward by his deputy, Mr. R. S. Pease, under the supervision of Mr. D. W. Fry, who is deputy director of Harwell with special responsibility for this work (see also preceding note). Dr. Thonemann will be available for consultation.

Physiology at the Medical College of St. Bartholomew's Hospital: Prof. K. J. Franklin, F.R.S.

THE news of Prof. K. J. Franklin's retirement from the chair of physiology at St. Bartholomew's Hospital

has been received with much regret by his many friends and former pupils. Franklin went to Oxford after service in the First World War. He obtained a first-class degree in the Final Honours School of Physiology, studied medicine at St. Bartholomew's Hospital and returned to Oxford as a Fellow of Oriel College in 1924. He was a demonstrator in pharmacology from then until 1935 when he was appointed assistant director of the Nuffield Institute for Medical Research. He was dean of the Oxford Medical School for many years, and went to St. Bartholomew's as professor of physiology in 1947. Prof. Franklin was very interested in the venous side of the cardiovascular system, an interest which led in 1933 to collaboration with Prof. Janker, of Bonn, one of the pioneers of X-ray cinematography. When the Nuffield Institute for Medical Research was established in 1935, special provision was made for the study of X-ray cinematography as applied to medical problems. Within a few years Franklin's foresight was justified by the first experimental demonstration of the course of the fœtal circulation. This work, in collaboration with Dr. A. E. Barclay and Sir Joseph Barcroft, finally settled a controversy which had lasted for nearly two centuries, and also provided the first direct evidence as to the nature of the changes in the circulation after birth. In 1947 the same method applied to the kidney led to the publication of some exciting and controversial "Studies of the Renal Circulation" in collaboration with Trueta, Barclay, Daniel and Prichard. Apart from Prof. Franklin's interest in the venous system (a "Monograph on Veins" was published in 1937, and "Cardiovascular Studies" in 1948), his meticulous researches into the history of physiology and his facsimile editions and translations of early writers on the circulation have earned the gratitude and respect of his colleagues. Within the past two years he has followed these with admirable translations of Harvey's "De Motu Cordis" and "De Circulatione Sanguinis".

Prof. M. de Burgh Daly

Prof. Michael de Burgh Daly, who has been appointed to succeed Prof. K. J. Franklin in the University chair of physiology at St. Bartholomew's Hospital Medical College, is also particularly interested in the control of the circulation and respiration. After taking the B.A. degree in Cambridge in 1944, he proceeded to St. Bartholomew's Hospital and qualified M.B., B.Chir. in 1947. After a house appointment, he joined Prof. G. L. (now Sir Lindor) Brown in the Department of Physiology at University College, London, and began research with the late Alfred Schweitzer. His interests in circulatory and respiratory physiology stem to some extent from the influence of Schweitzer and from that of his distinguished father, Dr. Ivan de Burgh Daly, until recently director of the Institute for Animal Research at Babraham, who has made great contributions to these subjects. Prof. de Burgh Daly spent 1952–53 in Philadelphia as Rockefeller Fellow in Prof. Schmidt's department. On his return he was appointed Locke Research Fellow of the Royal Society. His research activity has been considerable and fruitful. Among a long list of papers, notable have been those on the baroreceptor regulation of cardiac output, on the blood supply and oxygen usage of the carotid body and on chemoreflex responses of the pulmonary circulation.

Botany at Edinburgh : Prof. R. Brown, F.R.S.

The appointment of Dr. Robert Brown to the regius chair of botany in the University of Edinburgh, in succession to the late Sir William Wright-Smith, can scarcely fail to mark a new chapter in the history of botany in Scotland. The Department of Botany in Edinburgh has a long and honourable tradition of taxonomy, and Dr. Brown has achieved a notable reputation as a plant physiologist with a very individual outlook ; his activities in this new sphere will be watched with the liveliest interest. His earlier work includes contributions to the study of the stimulation of germination in seeds of the parasite *Striga* by root exudates from the host ; but the bias of his more recent researches has arisen from the development and imaginative exploitation of a powerful new technique for the estimation of cell numbers in growing-points and the tissues immediately behind them. The combination of a maceration technique with a hæmacytometer cell-counting method has made it possible to express the results of chemical and other estimations on a per cell basis. This has given the impetus to a remarkable series of studies of the development of cells from growing-points, carried out by Dr. Brown and his co-workers, first at Leeds and later (from 1953) in his very active Agricultural Research Council Unit of Plant Cell Physiology at Oxford. A brief summary of Dr. Brown's career appeared in *Nature* of October 11 (p. 992).

Pharmaceutical Society of Great Britain

A portrait of the late Prof. John Attfield, for thirty-four years professor of practical chemistry to the Pharmaceutical Society of Great Britain, was presented to the Society after the October meeting of the Council by his grandson, Mr. C. A. Brooks, of Dedham, Essex. The portrait is a replica of one given to Chicago pharmacists which was painted in recognition of the work done by Prof. Attfield in helping to "raise their College from its ashes after the Great Fire of 1871". With the portrait, Mr. Brooks handed to the Society a complete set of the nineteen editions of his grandfather's famous textbook of pharmaceutical chemistry and an album containing an illuminated address and 1,240 signatures of professional colleagues, including those of Lord Lister, Sir William Crookes and Sir Henry Wellcome. In accepting the gifts, Mr. Hudson, president of the Pharmaceutical Society, said they would be a perpetual reminder of the prominent place Prof. Attfield occupied in the Society's history and in the scientific world ; and of the services he had rendered to pharmacy and to medicine. He served the Society from 1862 until 1896. Probably, said Mr. Hudson, Attfield's greatest achievement was his work for the "British Pharmacopœia" ; and by the time of his death he had the satisfaction of knowing that it was legally adopted in all British Dominions.

Josiah Wedgwood and Research

In his 1957 presidential address to the North Staffordshire Field Club, J. Leighton directed attention to letters written by the famous eighteenth century potter, Josiah Wedgwood, to his colleague, and later, partner, Thomas Bentley (*Trans. N. Staff. Field Club*, 91 ; 1958). The letters show how, in company with other Staffordshire potters, Wedgwood planned so early as 1755–56 a co-operative research establishment for the pottery industry.

Following a patents dispute, proposals were made that a joint stock experimental company be established for the purpose of the general improvement of the manufacturers' products. Among the Wedgwood papers are the committee's "Heads of an Agreement, etc.", the first of which runs: "Proceedings in the scheme of an Experimental Work. The Commee. were of opinion that all who had subscribed to the opposition etc. shod. have a choice of becoming Members of a Company for carrying it into execution, and they were invited by circular letters, in consequence of which, they will meet on Tuesday next, when will be laid before the following Heads of an Agreement to be entered into. . . . We do mutually agree to establish an Experimental work for the purpose of trying the materials lately brought from Cornwall, as well as those which may in future come from that County as any other place in order to improve our present manufacture and make an Useful White Porcelain Body, with a colourless glaze for the same and a blue paint under the glaze. It was also proposed that no member shall disclose the experiments made by this Company or the knowledge obtained by them to any person or persons not in the Company, on pain of forfeiting his share in the joint Stock, and of incurring a penalty of One thousand pounds and that no one of us shall take advantage of the knowledge acquired by the experiments of this Society, by adopting any of the improvements made thereby in our own private manufactories or otherwise, until the plan and time of generally adopting and removing such improvements into the manufactory at large to be agreed upon by the Society under the penalty of One thousand pounds".

Unfortunately the plan came to nothing, but Wedgwood went on to write: "Having done my duty I am contented, and shall take my own course quietly by myself as I can, and may perhaps have it in my power to serve the trade some other way. . . . I shall now begin with the materials in earnest. I scarcely thought myself at liberty to do so whilst the Partnership plan was in agitation".

Historic Aircraft Maintenance Group

A GROUP of volunteers composed of members of the Royal Aeronautical Society and of the Society of Licensed Aircraft Engineers is about to begin work on repairing and maintaining the aircraft of the Nash Collection of historic aircraft now owned by the Royal Aeronautical Society. Since it acquired the Nash Collection in 1954, the Royal Aeronautical Society has had many difficulties in the storing and housing of the aircraft, but recently a hangar at the R.A.F. Station, Hendon, was made available. An appeal for volunteers living in the London area to work on the aircraft, made by the secretary of the Society in July this year, met with an enthusiastic response. Members of the two Societies are now starting work, giving up their week-ends to get these historic aircraft back to display condition. Captain E. D. Ayre, a past president of the Society of Licensed Aircraft Engineers, has been appointed chief engineer of the Historic Aircraft Maintenance Group. He has already undertaken a preliminary inspection of the aircraft and has started to collect the necessary equipment. Captain Ayre will supervise a team of engineers who have had extensive practical experience on the types of aircraft and engines in the Nash Collection. The guiding principles will be preservation rather than renovation, so ensuring that the craftsmanship of an earlier generation is not lost. It is hoped that, ultimately, the Society's Nash Collection will form part of a National Collection of Aircraft.

The Border Country in Britain

THE Forestry Commission's decision to declare the Border Country the eighth national forest park of Great Britain will give pleasure to all who have watched the planting, growth and development of the Forests of Kielder, Wark, Redesdale, Kershope, Newcastleton and Wauchorpe during the past thirty-five years. Their pleasure will be enhanced by the publication of a national forest park guide which worthily maintains the high standards of its predecessors (The Border. Edited by Prof. John Walton. National Forest Park Guides. Pp. vi+94+16 plates. London: H.M. Stationery Office, 1958. 5*s*. net). The bulk of the guide consists of accounts by H. L. Edlin of the land, the people, the poetry and legend of the Border, the Border forests and walks most likely to bring pleasure to nature-lovers. The Border region in Roman times is described by Prof. I. A. Richmond, and the history is continued by Prof. J. D. Mackie. Dr. W. A. Clark discusses the vegetation of the park, and Ernest Blezard the wild-animal life. The geology of the region is examined by Dr. G. A. L. Johnson. An extensive bibliography has been carefully built up by three prominent librarians. There is also the usual and indispensable section called "General Information"—which will help those who are new to the area to find their way about more quickly, profitably and, where appropriate, economically. Splendidly illustrated with verse, black-and-white sketches, photographs and maps, the guide is excellent value at 5*s*. The Forestry Commission and, particularly, Mr. Edlin deserve the highest praise for the quality of these publications.

Recent Phycological Publications

THE attention of readers interested in the problems of the algae may be directed to the *Phycological Bulletin* (No. 6, June 1958, pp. 1–53, issued by the British Phycological Society; *President*, Dr. J. W. G. Lund; *Hon. Editor*, Dr. Elsie Conway, Department of Botany, University of Glasgow). This issue gives a clear indication of the officers, construction and aims of the Society, namely, to pursue the scientific study of marine and freshwater algae on the widest basis. The contents include tributes to the late Dr. Kathleen M. Drew, who did so much to further the study of these organisms and to found the Society, abstracts of papers read at the London meeting in January 1958, and a variety of topics of both general and special interest to algologists. In particular, reference should be made to important tables of chromosome numbers in the Ulotrichales and in the brown algae, the authorship being cited in each instance. A volume of abstracts of the third International Seaweed Symposium, held in Galway, Eire, in August 1958, has also come to hand (pp. 1–82; University College, Galway). Some seventy-one papers, covering a very wide field, were submitted. These include such topics as biophysical and biochemical aspects of some algae, the possibilities of the mass culture of microscopic marine algae, their utilization as sources of raw materials, cytological and ecological studies, and so on. Yet a further contribution to algology comes from the Nova Scotia Research Foundation. This consists of a "Selected Bibliography on Algae" (No. 4. Pp. 1–109. Halifax, Nova Scotia), and includes references to chemical

and physical studies, culture, ecology, physiology, biology, morphology, taxonomy and utilization.

The World Health Organization

"An International Nomenclature of Yaws Lesions", by Dr. C. J. Hackett, in co-operation with an international group of experts and participants of the international conference on yaws control held at Enugu, Nigeria, in 1955 (World Health Organization Monograph Series No. 36. Pp. 103. Geneva: World Health Organization; London: H.M. Stationery Office, 1957. 12 Swiss francs; 20*s.*; 5 dollars), is an outstanding contribution to the study of the disease called, in English, 'yaws', in French 'pian', in German and Dutch 'frambœsia', in Spanish 'buba', and in Portuguese 'bouba'. The various names used in the study of the disease are defined, and the stages in the disease are described. There are seventy-six plates showing the frightful lesions caused by the spirochæte, *Treponema pertenue*, which is responsible for the disease. Some of these show the remarkable healing without scarring that may follow a single injection of penicillin. The nomenclature supersedes the earlier one given in the World Health Organization Monograph Series No. 5, entitled "Atlas of Frambœsia", by K. R. Hill, R. Kodijat and M. Sardadi, published in 1951. The successful reduction of yaws and the campaigns against it sponsored by the Organization and by UNICEF are described in "The First Ten Years of the World Health Organization" (pp. viii+540+28 pages of photographs. Geneva: World Health Organization; London: H.M. Stationery Office, 1958. 25*s.*; 5 dollars; 15 Swiss francs), which gives a comprehensive survey of its achievements in the many fields of health control and eradication of disease in which it operates all over the world. Another account of its achievements, illustrated by remarkable photographs of the work actually in progress, and attractively written by Ritchie Calder, is entitled "Ten Steps Forward, World Health 1948–58" (London: H.M. Stationery Office, 1958. 2*s.* 6*d.*).

Health in the Tropics

The report of the thirty-second meeting of the Ross Institute Industrial Advisory Committee on June 19 (pp. 19. London: London School of Hygiene and Tropical Medicine, incorporating the Ross Institute, 1958) records the address given by Dr. Alan Gilroy, principal of the India Branch of the Institute, and the subsequent discussion. Dr. Gilroy referred to the progress made in regard to malaria. In a large sample of tea-estate labour there were 12 cases of malaria per 1,000 in 1957, no deaths, and a spleen rate of only 1·5 per cent. As a result, with the adoption of a malaria-eradication programme by the Government of India, the industry could now contemplate relief from its recurring expenditure of nearly thirty years. Anæmia remained a most important cause of ill-health, and about 90 per cent of the cases are of simple iron-deficiency anæmia, although the diet was not short of iron and patients were not losing it to hookworm. In replying in the discussion, Dr. Gilroy said that the scientific investigation of malnutrition was as yet incomplete, but it appeared that although the diet was adequate in quantity it was deficient in quality. This was due to ignorance rather than to lack of purchasing power. Dr. Gilroy also said that the stage had been reached when it was accepted and recognized that family planning was necessary, and he also referred to the lecture courses in tropical hygiene for planters and the refresher courses held for tea-estate assistant medical officers.

City and Guilds of London Institute

The rapid growth of technical education in Great Britain and overseas is well brought out in the seventy-eighth annual report of the City and Guilds of London Institute, for the year October 1, 1956, to September 30, 1957 (Pp. v+118. London: City and Guilds of London Institute, Gresham College, 1958). In 1957, 119,948 students took one of the great variety of courses arranged by the Institute compared with 105,815 in 1956; it is not surprising to learn that 62·5 per cent of students in Great Britain and Ireland were successful in their examinations, whereas the number of successful overseas students was 48·1 per cent. Of the students, almost half of them (54,391) took courses in electrical subjects, 21,715 courses in mechanical engineering, 18,640 in building subjects, and 9,378 in chemistry subjects. Other courses taken were in domestic subjects, printing and food technology. Many of the courses were revised during the year and a number of new ones were added; among the latter is a course for a National Certificate in Agriculture for students who have completed a year at a farm institute. The report also contains details of the insignia awards in technology, the work of the art school and the City and Guilds College, as well as the response to examinations set by the Associated Examining Board for the General Certificate of Education.

The Cosmic Distance Scale

In his Warner Lecture before the American Astronomical Society, Dr. Allan Sandage has reviewed the current status of work on the cosmic distance scale (*Astrophysical Journal*, **127**, 513; 1958; *Sky and Telescope*, 17, 275; 1958). Hubble's criteria for setting up the distance scale have been re-examined. He used the brightness of the cepheid variable stars in the Andromeda and Triangulum nebulæ, the brightness of individual high-luminosity stars for somewhat more distant galaxies, and integrated apparent magnitudes of still more distant objects. The first criterion was revised in 1952 when Baade showed that classical cepheids were 1·5 magnitudes brighter than had been supposed: this effectively doubled the scale of distances. Other complicating features have since been discovered: the period-luminosity 'curve' seems to be a broad band, and new methods will have to be devised to find out whether individual cepheid variables are under- or over-luminous for their periods. One can therefore scarcely rely on the cepheid criterion for the thirty galaxies in which these stars can be seen with the 200-in. telescope.

Sandage has shown that Hubble's second criterion was incorrectly applied, in that many of the objects which Hubble believed to be bright stars were in fact ionized hydrogen regions; their nature only became evident when photographs were obtained through Hα filters. In the nebula *M* 100, for example, objects at magnitude 19·0 are ionized hydrogen regions, not stars, the brightest stars appearing at magnitude 20·8. If these individual stars have absolute magnitudes of $-8{\cdot}5$, the distance of *M* 100 would be

about six times its value on the 1936 distance scale; the Hubble constant of recession would be 87 km./sec./megaparsec. A similar result follows from studies of the globular clusters in the nebula *M* 87. These arguments do not constitute a rediscussion of the distance scale. Precise new measurements are required for this, and such measurements are now in progress at Mount Palomar.

Atoms for Peace Conference: American Publication

At the second International Conference on the Peaceful Uses of Atomic Energy recently held in Geneva, a set of twelve volumes dealing with the American participation, written expressly for the Conference and containing much information just declassified, was presented to official delegates as a gift from the United States. These volumes have now been published by Addison-Wesley Publishing Co., Inc., Reading, Mass., on behalf of the U.S. Atomic Energy Commission. (The volumes are also obtainable from Academic Books, Ltd., 129, Queensway, London, W.2.) The price of each separate volume varies from 45*s.* 6*d.* to 92*s.*; but the complete set is available at £30. Further information can be obtained from either the Addison-Wesley Publishing Co., Inc., or Academic Books, Ltd., at the above addresses.

Mammal Society of the British Isles

A symposium entitled "Mammals in British History and Prehistory" will be held in the meeting room of the Zoological Society of London, Regent's Park, on November 1. Non-members of the Society are invited to attend; there is no registration fee. The programme will include talks on the conditions for the preservation of mammalian remains, and blood grouping of human remains; the mammalian fauna and environmental conditions at the close of the Pleistocene; the mammalian fauna from Star Carr; and the historical development of farm animals in relation to their environment. Further details can be obtained from the conference secretary, Dr. K. M. Backhouse, Charing Cross Hospital Medical School, 62–65 Chandos Place, London, W.C.2.

Torry Research Station

The Council for Scientific and Industrial Research announces that responsibility for the research programme of the Torry Research Station at Aberdeen will be vested in a steering committee, consisting of: Dr. B. K. Blount (*chairman*), deputy secretary of the Department of Scientific and Industrial Research; Mr. G. C. Wilson, a member of the White Fish Authority and the Herring Industry Board; Dr. D. Traill, director of research of the Nobel Division of Imperial Chemical Industries at Stevenston, Ayrshire; Mr. H. Wooldridge, head of the Stations Division of Headquarters, Department of Scientific and Industrial Research; and the director of the Station, Dr. G. A. Reay. Dr. Reay's title was formerly 'superintendent', but it has now been changed to 'director'.

Announcements

Mr. J. Wilson has been awarded the Hinchley Medal of the British Association of Chemists for 1957. The formal presentation will be made at the Royal Society of Medicine (West Hall), 1 Wimpole Street, London, W.1, on October 29, at 7 p.m. Mr. Wilson will then deliver the Hinchley Memorial Address, which is entitled "Grant-aided Research Associations".

Mr. Alec M. Hughes, general secretary of the Scientific Film Association, has been appointed visual aids officer of the British Association for the Advancement of Science.

Mr. A. P. Gagnebin, who has been elected a vice-president of the International Nickel Company, Inc., joined the Company's research laboratory at Bayonne, New Jersey, in 1932 and devoted himself to research on ferrous metals. He became a member of the Ductile Iron Section of the International Nickel Company's Development and Research Division in 1949, where he was active in the industrial development of ductile iron, of which he is a co-inventor. In May 1952, Mr. Gagnebin was a co-recipient of the Peter L. Simpson Gold Medal of the American Foundrymen's Society, for outstanding work and development in the field of ductile iron. He is the author of many technical papers and of the book, "The Fundamentals of Iron and Steel Castings".

The British Council (65 Davies Street, London, W.1; telephone, Grosvenor 8011) asks senior academic scientists who are contemplating overseas tours (other than to the United States) to inform it of their intentions. The Council can often help with specialist contacts—and can sometimes arrange lectures by the traveller—in the countries to be visited or *en route*. Such collaboration is greatly valued by the Council as an important contribution to its efforts to promote a wider knowledge overseas of the sciences in Britain. Communications on this subject can be addressed to the Director, Specialist Tours Department.

The winter conference of the Physical Society, on physics of the solid state, will be held in the Cavendish Laboratory, Cambridge, during December 18–20. The subject of the conference will be interfacial phenomena, and it is hoped that papers will be given on some or all of the following subjects: (1) structure of vacuum-evaporated layers on single-crystal substrates; (2) structure of electrodeposited layers; (3) epitaxy; orientation of crystals on various substrates; (4) grain boundary phenomena; the interface between different phases in metals; (5) the interface between solid and liquid phases. Those wishing to take part are invited to write to Prof. N. F. Mott, Cavendish Laboratory, Cambridge.

The fourth Congress on Theoretical and Applied Mechanics will be held under the presidentship of Dr. S. R. Sen Gupta at the Bengal Engineering College, Howrah, Calcutta, during December 28–31. Research papers may be contributed on any of the following topics: (1) elasticity, plasticity, rheology; (2) fluid mechanics (aerodynamics, hydrodynamics); (3) mechanics of solids (ballistics, vibrations, friction-lubrication); (4) statistical mechanics, thermodynamics, heat transfer; (5) mathematics of physics and mechanics; and (6) experimental techniques. Registration forms and further information can be obtained from the Secretary-Treasurer, Indian Society of Theoretical and Applied Mechanics, Indian Institute of Technology, Kahragpur, India.

Erratum. Reference was made in the article entitled "Academic and Professional Mobility" in *Nature* of August 16, p. 413, to a paper by Dr. P. E. Weatherley; we regret that his name was wrongly spelled in that article and also in an earlier article (*Nature*, 181, 677; 1958).

ATMOSPHERIC DIFFUSION AND AIR POLLUTION

An international symposium on "Atmospheric Diffusion and Air Pollution", arranged jointly by the International Union of Theoretical and Applied Mechanics and the International Union of Geodesy and Geophysics, was held in Oxford during August 24–29. The symposium brought together from various countries nearly one hundred scientists, mainly meteorologists and fluid dynamicists, with active interests in one aspect or another of the physics of turbulent diffusion. The scientific programme was planned by a committee under the chairmanship of Sir Geoffrey Taylor and the joint secretaryship of Dr. F. N. Frenkiel (Johns Hopkins University) and Prof. P. A. Sheppard (Imperial College of Science and Technology, London), and was expressly designed to examine outstanding basic problems in the study of atmospheric diffusion and its application to air pollution studies. Accordingly, after an opening session which included broad surveys of the distribution and effects of the airborne products of combustion, conventional industrial processes and nuclear processes, the proceedings were organized into sessions dealing with specific aspects of the problem of diffusion. These included the structure of atmospheric turbulence, the theoretical treatment of the diffusion of particles in a turbulent atmosphere, the processes of vertical transfer on all scales in the atmosphere and the effect of thermal stratification thereon, and the distribution of airborne material from artificial sources.

As nearly forty papers were presented, this article would be little more than a catalogue if all were to be mentioned individually. For such detail the reader will shortly be able to turn elsewhere, for the entire proceedings of the symposium, both papers and discussions, are to be published in book form by Academic Press, Ltd., and it is hoped that they will appear before the end of the year. The aim of this article is rather to comment on some of the major issues brought out in the proceedings.

The scientific treatment of atmospheric diffusion was effectively started by Sir Geoffrey Taylor in 1915 in his classical work on the vertical transfer of heat and momentum by eddies in the atmosphere. This work was the beginning of one of the two main approaches to the subject, the approach which is concerned with the 'bulk' properties of the fluid, especially the gradients of the mean properties undergoing diffusion, as distinct from the other main approach involving preoccupation with the internal structure of the fluid. The real beginning of this latter approach was also provided by Taylor, in 1921, in a paper in which diffusion was related to the correlation between the eddy velocities of a given element of fluid at specified times. Then in 1926 L. F. Richardson put forward a novel theory of atmospheric diffusion which implicitly recognized the existence and importance of a whole spectrum of eddy sizes in turbulent motion. More explicit use of the idea of a spectrum came later, at first in a purely formal sense, in the general theory of the statistical mechanics of isotropic turbulence, initiated by Taylor in 1935 and followed up more recently by G. K. Batchelor and others. From a physical point of view, an important step in the development of the concept came with A. N. Kolmogoroff's set of simplifying hypotheses concerning the transfer of turbulent energy from large eddies to small eddies. Although these ideas were put forward in 1941, owing to the Second World War they did not begin to be widely known until nearly ten years later. The fundamental ideas involved in these earlier advances still dominate the background against which the Oxford discussions were conducted.

The contributions on the structure of atmospheric turbulence all indicated the tendency, which has grown rapidly, especially over the past five years or so, to represent this turbulence on the statistical basis which has been so highly developed in the study of wind-tunnel turbulence. Owing to the large range of eddy sizes normally present in the atmosphere, the emphasis has naturally been more on the spectrum of eddy energy than on the time- or space-correlations of the velocity fluctuations, though in practice the time-correlations (from velocity observations at a fixed point) are obtained as an essential intermediate step. The 'power-spectra' derived from them by Fourier transform techniques give the intensities of the contributions, to the total variance of the velocity component, from oscillations of particular frequencies which are contained in the time-variation of the component. These 'time-spectra' are strictly to be distinguished from the so-called Eulerian 'space-spectra', which are correspondingly derived from simultaneous velocity measurements at many fixed points, and which contain a more satisfactory physical representation of the eddy 'size'. However, it has been customary for some time to assume equivalence of the more easily obtained 'time-spectra' with space-spectra in the direction of the mean motion, and evidence on this continues to accumulate.

Two features which were brought out concerning the shape of the spectrum are especially worthy of mention here. If the spectra for the vertical component at heights varying from one to a few hundred metres are 'normalized', by plotting the product of the equivalent wave-number (the reciprocal of the wave-length) and the spectral intensity against the product of the wave-number and the height, there appears to be a general similarity in shape, with a maximum intensity at a wave-length of the order of three times the height above ground. The other features concern behaviour at higher frequencies, where, according to the ideas put forward by Kolmogoroff, all forms of turbulence should exhibit isotropic properties, that is to say, properties which are unaffected by rotation of the axes of reference. The data now accumulating leave no doubt that the limiting eddy size, below which the isotropic structure exists, increases with increasing height above ground, and recent measurements confirm an earlier suggestion that the isotropic limit occurs at an equivalent wave-length approximately equal to the height. Both of these generalizations may well require some qualification when appreciable thermal stratification of the atmosphere is involved, but they represent useful

first steps in the provision of an integrated description of atmospheric turbulence.

In the papers relevant to the vertical transfer of momentum and heat in the lower atmosphere, it was encouraging to see the Navier–Stokes equations of fluid motion being used as a starting point for understanding some of the stages in the complex cycle of energy exchange in stabilized and unstable flow. On the other hand, it was evident that some confusion still exists in the empirical description of the effects of thermal stratification. All seems reasonably straightforward so long as the atmosphere is in neutral or near-neutral equilibrium, when the adoption of the familiar universal wind profile (wind velocity varying with the logarithm of the height) enables the flux of momentum (and of other properties) to be usefully estimated merely from measurements of the vertical gradients of wind velocity and of the properties concerned. The long-required extension of this sort of treatment to the cases when the atmosphere is heated or cooled from below has recently seemed to be forthcoming from dimensional analysis. These treatments certainly lead to wind profiles of the required shape in stable and unstable conditions, and also to the correct qualitative variation of vertical flux with degree of stability, but at this point the consistency appears to end. In the first place, there are important differences, which have yet to be explained, in independent measurements of the vertical transfer of momentum near the ground. Furthermore, it seems that the magnitudes of the dimensionless parameters required by the form of the wind profile are of a different order from those required to explain the absolute magnitude of the vertical flux. Since one of the practical interests lies in being able to estimate flux quantities from profile measurements, these discrepancies are frustrating as well as puzzling, and their resolution would represent an advance of some practical importance.

It may be that the resolution of these difficulties will only come as a result of closer attention to the structural properties, as in one of the contributions, where for two specific cases with unstable conditions it was demonstrated that the vertical motions responsible for heat transfer were of larger scale than those responsible for momentum transfer. Moreover, from a number of points there are reminders that with increasing instability and with increasing height above the surface boundary the dominant character of the vertical motion changes from that of mechanically generated turbulence to the more organized motions of thermal convection. Some progress has already been achieved in the representation of the heat transfer by these organized motions, but a useful statistical derivation of the transfer of momentum and other properties has evidently yet to emerge.

In the theoretical treatment of the distribution of particles released in a turbulent fluid increasing use is now being made of the mathematical and statistical techniques which were evolved largely in relation to aerodynamic problems. Many of the developments are still in a highly formalized stage, and the progress made towards rigorous solutions which can be expressed in terms of measurable properties of the turbulence is not immediately obvious. However, one real improvement is to be noted in the more detailed attention which is being paid to the significance of the finite time involved in observing diffusion phenomena. The need for this attention arises directly from the 'width' of the turbulence spectrum, and becomes the more pressing in the case of atmospheric flow, where for many problems the spectrum extends effectively indefinitely into the region of long wave-lengths. Another welcome sign is the increasing recognition of the distinction between the distribution of particles relative to fixed axes after continuous release from a fixed point, and the relative spread of particles released instantaneously in a cluster. These ideas are being adopted to an encouraging degree in a 'model' treatment of the statistical properties of the continuous plume from a fixed source of particles. The accumulation of satisfactory observations on the relative spread of particles is now an outstanding requirement.

Despite these more advanced exploitations of the statistical theories of turbulence, a central problem still remains in the interpretation of the Lagrangian variations of the motion, that is to say, the variations in the velocity of a particle in contrast to the variations which may easily be observed at fixed points in the fluid. This problem was presented from the beginning in Taylor's 1921 analysis, by which the diffusion from a serial release of particles is specified in terms of the Lagrangian correlation coefficient, namely, that between the velocities of a particle at successive instants of time. The gap between this virtually unmeasurable property and the measurable time or space correlations at fixed points has yet to be bridged, and the fluid dynamicists are not yet able to offer any hope of this being achieved soon in the circumstances of concern to the meteorologist.

In the absence of a tractable analytical relation between these Lagrangian and Eulerian properties the realization of the practical end-point in the present subject, that is, the formation of realistic estimates of the distribution of airborne material released in a specified fashion, continues to lean heavily on empirical devices or careful limitation of the physical conditions involved. The latter recourse seems to be used with promising effect in contributions to the diffusion of falling particles with terminal velocities of a limited range, large enough to ensure that Eulerian variations are dominant over Lagrangian variations, yet small enough to exclude serious inertial effects on the response of the particles to the turbulent fluctuations. For floating particles some immediate progress is provided by the empirical step of assuming a simple relation between the Lagrangian correlation function and the auto-correlation function measurable at a fixed point. This has led to a method of obtaining the spread from a continuous point source directly and simply from measurements of velocity fluctuations.

The attainment of rational, albeit empirical, formulæ and methods for predicting diffusion is still mainly confined to the small-scale processes involved in diffusion over a few hundred metres. On the largest scale, involving exchange within and between the troposphere and stratosphere, the position is still one of gaining experience from the behaviour of natural and man-made tracer elements. Much interesting information is accumulating from measurements of fall-out from nuclear tests, and some of this is thought to fit in with current ideas of stratospheric motion based on studies of water vapour and ozone. Another promising radioactive tracer has been recognized in the isotopes produced by cosmic radiation. These have the advantage of being produced practically independently of time and without seasonal or diurnal changes. For the inter-

mediate scale of diffusion, the sort involved in the travel of radioactive material from the Windscale reactor accident in October 1957, little progress has been reported. On this scale, involving heights of several thousands of feet and distances of tens of miles, the processes of dispersal are further complicated on one hand by the variation of the mean wind field with height, and on the other hand by the large-scale effects of thermal stratification, leading alternatively to the virtually complete suppression of vertical spread or to rapid ascent in organized convective motion. From a practical point of view, it is to this scale of processes that attention is most urgently required.

F. Pasquill

FUTURE OF MINERAL EXPLORATION IN GREAT BRITAIN AND IRELAND

THE fourth Sir Julius Wernher Memorial Lecture of the Institution of Mining and Metallurgy was given by Mr. Anton Gray, mining adviser to the U.K. Atomic Energy Authority, at the Royal Institution on September 22, his subject being "The Future of Mineral Exploration". In a survey of the world situation, Mr. Gray maintained that whereas it is unlikely that the present rapid rate of increase of consumption of metals can be maintained, it would not be surprising if the demand for the major metals doubles before the end of the present century. About the beginning of this century the geologist began to take over the work of the prospector, for by then most of the mineral deposits not concealed by younger formations had been found. But he has not had the same success in the search for a method of predicting the occurrence of ore-bodies as his colleague in the petroleum industry has had in finding concealed oil-pools.

This results from his inadequate knowledge of the precise mode of origin of mineral concentrations; for while it is generally agreed that most important ore-bodies were introduced into openings in pre-existing rocks by warm waters, there is no agreement as to the source of the water or of the contained metals. The dominant hypothesis, that of hydrothermal solutions related to granite, had been shown, in Mr. Gray's view, to be adequate only for a limited group of metals, including tin, tungsten, beryllium and some gold concentrations. He suggested an unorthodox but not heretical alternative for the other metals: that the waters are generated during metamorphism associated with mountain-building, and he based this suggestion on two of the great ore deposits of the world, the central African copper belt and the Witwatersrand goldfield. The great part which Mr. Gray has played in mineral exploration in central Africa lends authority to his advocacy of this hypothesis of what might be called metamorphic lateral secretion.

This lecture formed a prelude to a symposium on "The Future of Non-Ferrous Mining in Great Britain and Ireland", held at the Federation of British Industries on September 23–24. The symposium consisted of twenty-four papers, in three broad groups: a series of seventeen devoted to descriptions of the geology, mining history and potentialities of the mineralized districts of Ireland, Scotland, England and Wales; a group of short contributions on technical aids to mineral exploration, such as the various geophysical methods, the use of geochemical prospecting techniques and of air photography; and a series on economics and finance.

The foundation for an approach to the geological problems of the mineral fields was laid during the past century by the official primary 6-in. Geological Survey of Great Britain and Ireland, but with the decline of the tin, copper and lead mines, there was little further interest in the subject until recently. The Special Reports on Mineral Resources of the Geological Survey, chiefly based on work done during the First World War, brought together much valuable data, but it is probably fair to say that geological investigation by modern methods has been confined to the past two decades. The papers in the first group gave a fair conspectus of the conclusions reached. As is well known, the mineral fields in the British Isles occur in granite and adjacent Devonian–Carboniferous slate in the south-western counties of England; and elsewhere chiefly in two main environments, the Lower Palæozoic slates and very low-grade metamorphics; and the unmetamorphosed Lower Carboniferous rocks, chiefly of limestone or 'Yoredale' facies. A stratigraphical control—that is to say, a strict relationship between particular beds or lithologies and introduced mineral bodies—is postulated by W. J. Hughes in central Wales, by A. A. Archer in north Wales, and by H. G. Dines in west Shropshire, in all these cases in Lower Palæozoic strata; but in other districts where the rocks are of similar age, such as the Lake District (T. Eastwood) or Leadhills–Wanlockhead (R. A. Mackay), no such control has been found. Thus, while the ore-shoots, though steeply inclined, tend to be elongated ribbons where they are related to the stratigraphy, where they are not—as, for example, in the Greenside lead or Coniston copper mines—the two major dimensions tend to be roughly equal. In the Carboniferous fields of the Pennines and Flint–Denbigh there is a very well-marked relation to brittle beds such as sandstone and limestone, as well as to chemically reactive wallrocks such as limestone and dolerite; and the influence of impermeable or semi-permeable shales or rotted lavas overlying favourable strata is important in localizing ore-bodies. It follows that in these districts, as well as in many Lower Palæozoic fields, ore-bodies occur which fail to outcrop. Some of these have been found by underground operations, but nearly all districts contain areas suitable for prospecting for concealed mineral deposits, some of them of substantial promise. This is the chief basis for the view that British metalliferous deposits are far from exhausted.

A second line of geological approach is the study of the spatial distribution of mineral species in individual districts. The zonal pattern in Cornwall

is well known and has been clarified by Dines, as well as in K. F. G. Hosking and J. H. Trounson's contribution to the symposium. Zoning has been demonstrated in the northern and southern Pennines by the present writer, broadly corresponding with the outer zones of Cornwall, but lateral rather than vertical in effect. It can be discerned in individual deposits like Bridford, Devon, described by P. G. L. Vipan, in a downward change from barite to sulphides, and Archer notes a broad though probably not genetic zoning in north Wales.

Most important of all, the localization of introduced mineral deposits is controlled by structural features, particularly by fractures which resulted from successive periods of stress and which form a definite pattern in each field; but also by granite cupolas, by folds of various dimensions and even by pre-ore dykes. At Leadhills–Wanlockhead a thrust plane is recognized as the operative control by Mackay. Displacement of ore-bodies by faulting after emplacement also occurred in many districts; in the northern Pennines this may have thickened some oreshoots locally. For Derbyshire it was suggested by W. W. Varvill that definite belts of rich mineralization, oblique to the superficial structure, could be recognized; perhaps these are related to trends in the concealed basement rocks.

Though more detailed structural information is desired in every district, the chief obstacle to successful prediction is present ignorance of the origin of the mineralizing fluids and their paths of ascent. A clear genetic relation to granite is demonstrable only in the south-west of England, and here it is interesting to note that Hosking's interpretation of the form of the granite batholith in depth, based on the distribution of mineral veins, corresponds remarkably closely with the quite independent interpretation based on gravity survey recently presented to the Royal Society by M. H. P. Bott, A. A. Day and D. Masson-Smith. There is evidence of concealed granites beneath the northern Pennines from the gravitational data of Bott and Masson-Smith, but the connexion with mineralization remains to be proved by deep boring. In many other districts, no hint has so far been found of such a connexion. There is, however, evidence from boring that mineralization persists to much greater depths than mining has so far reached, for example at Halkyn, described by G. A. Schnellmann, and east of the north Derbyshire district.

The geological age of the deposits has little bearing on their future value, but it is to be noted that on this aspect some new evidence was forthcoming. A. Fowler showed that the Conlig lead vein near Belfast follows a dolerite dyke of probable Tertiary age; while conversely Archer found that a dyke of the same age cuts through a lead lode at Parc in the Conway valley.

The mineral deposits of the Republic of Ireland, described by M. V. O'Brien, include at Avoca a deposit in Lower Palæozoic slates which has been developed with success in recent years, and which promises to be a major source of copper ore and pyrite. This work, financed by the Government and leading to the revival of a dead industry, exercised a considerable influence upon the discussions at the symposium. The small non-ferrous mining industry in the United Kingdom could be expanded if, using the geological basis which is now becoming available, techniques such as electromagnetic and shallow seismic survey, and geochemical soil sampling, were followed up by vigorous boring programmes. J. S. Webb's work at Gregory in Derbyshire showed how a lead deposit, deeply concealed under shale and grit, yet betrayed its presence by a leakage-dispersion at surface. The hope for the future is in the 'concealed areas', a conclusion emphasized by A. J. P. Walter.

The papers contributed to the symposium were available as pre-prints, but a collected volume, including the discussion, is to be published.

K. C. DUNHAM

THE NATIONAL STANDARDS LABORATORY OF AUSTRALIA

DIVISION OF METROLOGY

THE work described in the annual report for 1956–57 of the Division of Metrology of the Australian National Standards Laboratory extends over a wide field and is of interest to the physicist and the engineer, to the laboratory worker and the industrialist, who are concerned with standardization and fine measurement. The primary objects of the work are the maintenance and improvement of the Commonwealth standards, the development of improved techniques of measurement and providing assistance to industry. The need for standardization and co-operation at international level is clearly recognized and accepted as an important responsibility; considerable effort has been devoted to this end, particularly in the field of length-measurements by the up-to-date techniques of optical interferometry. It has involved world-wide travel to participate personally in deliberations under the auspices of the International Committee of Weights and Measures and of the International Convention for Legal Metrology, and to make personal contact with those engaged in similar work in comparable institutions in other parts of the globe. Incidentally, the report from the section which deals with line standards indicates very clearly the difficulties of establishing and maintaining precise standards of length on the present basis of a material metre bar in the custody of an institution half the world away. Australia will stand to gain as much as any nation from the international adoption, envisaged for 1960, of a wave-length definition of the metre.

In this brief note one cannot hope to do full justice to the many activities reported, and the remaining comment will therefore be confined to a few points. For example, it is noticed that the National Standards Laboratory has been able to extend its help beyond the borders of Australia in the verification of standards of mass and that its own accuracy of weighing, already high, is to be refined by means of a special balance ordered for the purpose. The fact that the section leader responsible for this work is also concerned with such diverse matters as barometry,

density, photogrammetry, measurements of time and fluid flow and the investigation of lapping techniques illustrates the breadth of the need for precise measurement and development in basic techniques.

In the general field of engineering dimensional metrology, assistance is given to industry by testing measuring equipment of all types, machine tools and workpieces, by advice on the design of precision measuring apparatus, and by providing practical help in the alignment of large-scale engineering structures. The air gauging technique is being applied to the development of special measuring equipment.

Other needs of the engineer receive the attention of the Applied Mechanics Section, which is responsible for the measurement of force (load), pressure and hardness, and conducts research in vibration, engineering design, production processes and the mechanical aspects of machining. This Section is equipped for the measurement of load up to 500 tons-force in compression and 50 tons-force in tension, for the measurement of hardness in the usual scales, and has deadweight pressure gauge testers ranging up to 30,000 pounds-force per square inch.

Particular attention has been paid to the factors governing the functional requirements of an engineering product in relation to production and inspection, and the results of analytical study of these factors are being widely disseminated by publication and lecturing. In parallel, and in support, research is being conducted to determine the factors in machining which control dimensional frequency distribution, tool wear and tool life.

A small but active Electronics Section has been busy applying electronic techniques to a variety of problems such as a pressure controller for barometry and the measurement of the periodic errors in machine tools and of cutting forces in research on machinability. It is to be expected that this Section will be expanded in due course in order to reap more fully the advantages in accuracy and flexibility which electronic techniques can bring to precise measurement.

Returning to the subject of vibration, it is recorded that the demand for vibration testing and consultative services have seriously reduced progress on main research projects and that certain of the Division's equipment has had to be moved to a site shown by a vibration survey to be less objectionable. The simultaneous growth of the need for more powerful machines and equipment and for greater refinement of measurement presents a growing problem of particular importance to all metrologists, a problem which will become increasingly difficult to solve without forethought on the part of all concerned.

The staff of about three dozen research officers and technical officers, helped by an equal number of technical assistants, during the year published nearly a dozen papers and had some half a dozen further papers ready for publication. Indicative of the high regard in which the work of the Division of Metrology is held is the recent appointment[1] of its chief, Mr. N. A. Esserman, as the first director of the National Standards Laboratory. This is stated to be one of the first consequences of the recommendations made by a committee of the Advisory Council which reported last year on the future development of the Laboratory. Mr. Esserman remains directly responsible for the work of the Division.

[1] *Nature*, **182**, 291 (1958).

BRISTOL CITY MUSEUM

THE report of the City of Bristol Museum for 1957* continues the series of readable, well-produced and attractively illustrated publications issued annually by that Museum, in which it also continues to record a commendable extension of activities and responsibilities, evidenced by the introductory matter on the personnel and scope of committees and sub-committees on general museum work, on staffing and policy, on the preservation of ancient Bristol and on the Museum School Service. The latter, for years an informal advisory committee, has now become fully official, reflecting the increased volume of, and value placed upon, the work the Museum does for the schools of the area. It is presided over by the chairman of the City Museum and Art Gallery Committee, and its members include teachers serving in Bristol schools and representatives of departments of education.

Staff matters reflect the health of any museum. In this report, loyalty and long service to a respected institution are reflected in the retirement of the administrative assistant after forty-five years service —thirty-three years of which were with the Museum and Art Gallery—and of the museum foreman after twenty-two years. One member of the staff has obtained an M.A. degree and another the diploma of the Museums Association, while a third has left to take up a curatorial post in another institution. The director and staff also figure as officers or members of a variety of learned societies and advisory bodies, both national and local, and the list of research work accomplished and papers published is clear evidence of a busy institution.

The acquisition of Chatterton House, the birthplace of the boy-poet Thomas Chatterton, thanks to the generous intervention of the Dulverton Trust, adds to the many attractions Bristol Museum can offer. Temporary exhibitions continue to be a major offering to townspeople and visitors—a post-war feature of museums' activities, which take much time and give much trouble, but which are greatly worthwhile. The lenders range from the city librarian and city archivist to the Victoria and Albert Museum in London. Publications produced include a "Guide to Roman Buildings in Kings Weston Park" and leaflets on the Folk Museum at Blaise Castle House, as well as programmes of a highly successful series of winter lectures and summer conducted walks to places of historical or scientific interest in the neighbourhood. The services rendered are varied—from providing an attractive venue for official receptions given by the Lord Mayor, the Sheriff and the Vice-chancellor of the University of Bristol to housing a training course for students for the diploma of the Museums Association.

Departmental reports record valuable work on the coin collections, greatly used for reference purposes,

* The City Museum, Bristol. Report of Committee for the year ended 31 December, 1957. Pp. 23. (Bristol: The City Museum, 1958.)

new exhibits on African ethnology, primitive shipping, berries and twigs, British Lepidoptera for beginners and metalliferous mining in the Mendip Hills, and a new room devoted to Georgian costume as a contrast to the already popular Victorian room. The new Department of Conservation is proving its great worth and has a lengthy and interesting list of repairs completed, treatments accomplished, models made and exhibits prepared to its credit. Its organization has been greatly helped by the Works Laboratory of the Bristol Aeroplane Company—an interesting example of co-operation. Special reference is due to the work for schools, for which an additional assistant organizer has been appointed. Lessons in history, biology, geology and geography are given to an ever-increasing number of classes, and it is gratifying to note that children from nearly one-third of all the junior and secondary schools in Bristol attend, while the School Loan Services, with a better collection than ever before of specimens, models and photographs, are used by more than 70 per cent of the schools in the Bristol area. Teachers in training in seven institutions visit the Museum to learn how best to use museum facilities in their future professional practice. At the other end of the scale, the Saturday Club continues to enjoy an enthusiastic membership of young naturalists aged 9–11 years.

D. A. ALLAN

SOME PROBLEMS OF SMALL FIRMS

A SHORT report published by the Department of Scientific and Industrial Research gives details of one of the most encouraging services to industry carried out under its auspices*. It is a commonplace that the economic prosperity of Great Britain would be secure if a fair proportion of the many small firms and medium-sized firms could be brought up to a standard of efficiency equal to that of some of the bigger firms. One of the difficulties is that, hitherto, there has been an unbridged gap between research institutions with their store of valuable knowledge and the small and medium-sized firms who might well use this knowledge but lack trained scientists and technologists to guide them to it. This report describes the work of a technical liaison service which was organized in 1955–56 by the Scottish Council (Development and Industry), the broad purpose of which is to promote the economic development and well-being of Scotland. A team of three investigators, all men who had retired from responsible managerial or technical posts in industry, visited small and medium-sized engineering firms in the industrial belt of Central Scotland to find out what problems confront the smaller firms in the drive for greater efficiency and expansion; what equipment they possess for solving these problems for themselves; where to get help; and in what ways external sources could help.

During the survey the technical liaison service helped 109 firms, each with fewer than five hundred employees and with no elaborate management organization, to find solutions to 223 problems which they could not overcome with their own resources. Every interested firm was visited by a member of the team who helped to define each problem precisely and then to find a solution. Some questions could be answered on the spot from the member's own experience; the rest were referred to the Scottish Council's office in Edinburgh, where the technical co-ordinator of the project got in touch with the most likely sources of information.

The work of the experimental technical liaison service disclosed that:

(1) Firms in the survey were relying predominantly on trade contracts and other firms for information on new developments and techniques, and were accordingly in danger of operating within a closed circle.

(2) A few firms had ample technical resources, but most had few or none.

(3) Although many of the firms seemed to be attempting creative adjustments to new circumstances, only ten of them were managing to do so without introducing violent and disruptive changes. There were many reasons for this, but a predominant one was lack of technical information on which long-term plans could be based.

(4) Most firms were having difficulty in answering, from their own resources, some of the problems which affected their future plans; they discussed these with the technical liaison service.

(5) Half the problems had been previously abandoned, or were defined for the first time during discussions with the team, or with the staff of research and other organizations introduced by them.

(6) Answers to more than 70 per cent of the problems were found by the technical liaison service during the survey. The information required was in existence, but its sources unknown to, or unused by, the firms.

The outstanding success of the technical liaison service led the steering committee of the Scottish Council to recommend that a permanent technical liaison service should be provided; at first it would help small and medium-sized engineering firms, as the experimental service had done, but later it should be extended to other industries. The Committee indicated that the operation of regional schemes on these lines should be in the charge of the Department of Scientific and Industrial Research and suggested that the Secretary of State for Scotland should be asked if an official service could be provided. Meanwhile, the Committee felt that the service was so urgently needed that it should be run by a private Scottish institution until an official scheme could be established—preferably by an independent organization, like the Royal College of Science and Technology at Glasgow, since the experimental service gained much from the support of technical colleges and from easy access to technically qualified staff with industrial training.

The Scottish Education Department has recently authorized the expenditure required to set up a technical information service, on the lines proposed by the Scottish Council's steering committee, under the Department of Industrial Administration at the Royal College of Science and Technology, Glasgow. This extension of the Department's work is largely experimental and will be revised in not more than three years.

* Small Firms with Big Problems: a Short Account of an Experimental Technical Liaison Service run by the Scottish Council (Development and Industry). Pp. iii+24. (London: Department of Scientific and Industrial Research, 1958.)

CONTRIBUTION OF HIGH-ENERGY PARTICLES TO THERMONUCLEAR REACTION RATES

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AND
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IN the course of work on a general study of the feasibility of thermonuclear power generation, we have examined the reactions :

$$^2_1D + ^2_1D \rightarrow ^3_2H + ^1_0n\ (3{\cdot}265 \pm 0{\cdot}018)\ \text{MeV. (ref. 1)} \quad (1)$$

$$^2_1D + ^2_1D \rightarrow ^3_1T + ^1_1p\ (0{\cdot}0136 \pm 0{\cdot}022)\ \text{MeV. (ref. 1)} \quad (2)$$

$$^3_1T + ^2_1D \rightarrow ^4_2He + ^1_0n\ (17{\cdot}577 \pm 0{\cdot}02)\ \text{MeV.} \quad (3)$$

In view of the recent experimental results obtained by means of ZETA at Harwell[2] it seemed to us worth while to communicate some of our results concerning thermonuclear reaction-rates. These results show in detail the contribution of particles of various energy groups to the total reaction-rates. It will be seen that in all cases considered the main contribution comes from a rather small number of particles with energy much higher than the mean thermal energy of the particles.

Attention was directed to this fact by Post[3], who points out that "the tail of the Maxwell distribution wags the dog". These results point to the possibility of using acceleration processes within a gas discharge for the purpose of production of fusion power. The Harwell results quoted above indicate that the neutron yield of ZETA is in fact due to non-equilibrium processes.

The reaction-rate in a hot plasma with nuclei of type A and of velocity $u = (u_1, u_2, u_3)$ and type B of velocity $v = (v_1, v_2, v_3)$ is given by :

$$R_{AB} = \int_{-\infty}^{\infty} f(u_1)\mathrm{d}u_1 \int_{-\infty}^{\infty} f(u_2)\mathrm{d}u_2 \int_{-\infty}^{\infty} f(u_3)\mathrm{d}u_3 \int_{-\infty}^{\infty} g(v_1)\mathrm{d}v_1 \int_{-\infty}^{\infty} g(v_2)\mathrm{d}v_2 \int_{-\infty}^{\infty} g(v_3)\mathrm{d}v_3 . \sigma(w) \quad (4)$$

where f and g are velocity distribution functions such that the particle numbers in a volume element of velocity space are given by :

$$\mathrm{d}n_A = f(u_1)\, f(u_2)\, f(u_3)\, \mathrm{d}u_1\, \mathrm{d}u_2\, \mathrm{d}u_3$$
$$\mathrm{d}n_B = g(v_1)\, g(v_2)\, g(v_3)\, \mathrm{d}v_1\, \mathrm{d}v_2\, \mathrm{d}v_3$$

and w is the absolute value of the relative velocity :

$$w = \left| \vec{u} - \vec{v} \right| \quad (5)$$

while $\sigma(w)$ is the cross-section of the reaction between A and B. When the velocity distribution is Maxwellian, it is easy to show from (4) that in a system where the nuclei B are at rest and the nuclei A have velocity w and kinetic energy $E = m_A w^2/2$:

$$R_{AB} = (8\pi n_A n_B/m^2{}_A)\,(m/2\pi kT)^{3/2} \int_0^{\infty} E\sigma_{AB}(E) \exp\left(-mE/m_A kT\right)\mathrm{d}E \quad (6)$$

where m is the reduced mass :

$$m_A \,.\, m_B \,/\, (m_A + m_B)$$

and $\sigma_{AB}(E)$ is the cross-section of the reaction between A and B.

Gamov and Teller[4] have shown that the cross-section for penetration of a Coulomb barrier of height $Z_A Z_B e^2/r_0$ between nuclei of atomic numbers Z_A and Z_B and masses m_A and m_B is given by :

$$\sigma_{AB} = A/E \exp(-B\,E^{-1/2}) \quad (7)$$

where

$$A = (m_A \pi \hbar^2/2m^2) \exp(4/\hbar)\ (2m\, Z_A Z_B e^2 r_0)^{1/2}$$
$$B = \pi Z_A Z_B\, \alpha_f (2m_A c^2)^{1/2}$$

and α_f is the fine-structure constant.

At low energy the fusion cross-section is of the form :

$$\ln E\sigma_{AB} = A' - E^{-1/2}B' \quad (8)$$

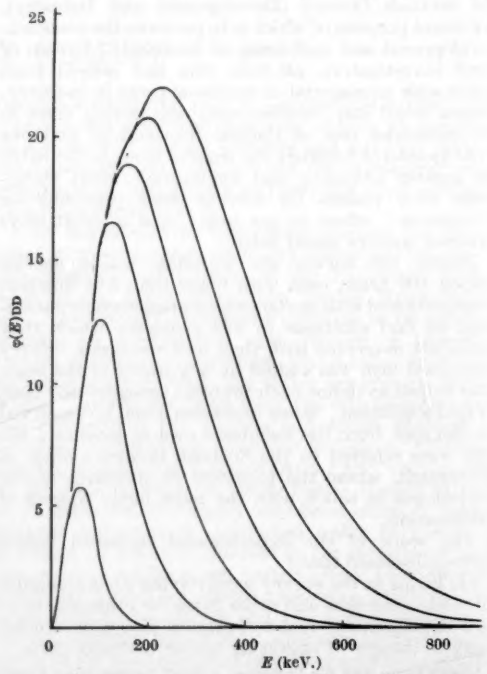

Fig. 1. Contribution to the reaction rate R_{DD} as a function of the deuteron energy E for kT = (left to right) 10, 20, 30, 40, 50, 60 keV.

We have determined the constants A' and B' from the experimental data for reactions (1), (2) and (3) as determined by Arnold and co-workers[5].

At higher deuteron energies for reaction (3) the experimental results of Argo and co-workers[6] were used. These experiments were carried out with triton beams of energy E_T in the laboratory system. Transforming to the system where the tritons are at rest the corresponding deuteron energies are given by:

$$E_D = (m_D/m_T)E_T = 0{\cdot}6677\ E_T$$

The cross-sections for reaction (2) have been measured by Wenzel and Whaling[7]. The total cross-section for reactions (1) and (2) has been determined by McNeill and Keyser[8] and the ratio of the cross-sections (1) and (2) has been determined by McNeill, Thoneman and Price[9]. Low energy measurements for reaction (2) by Moffat, Roaf and Sanders[10,11] are also available. We have computed the total reaction rate $R_{DD} = R_1 + R_2$ and $R_{DT} = R_3$, where the suffixes refer to the processes listed above. Formula (6) was used, which becomes:

$$R_2 = (n_D\text{cm.}^3)^2\ 10^{-21}\ \text{cm.}^{-3}\ \text{sec.}^{-1}\int_0^\infty \varphi_2(E)\,\mathrm{d}\,(E/\text{keV.}) \quad (9)$$

where

$$\varphi_2(E) = 8{\cdot}733\ (kT/\text{keV.})^{-3/2}\ \exp(-E/2kT)\ (\sigma_2(E)E/\text{millibarn/keV.})$$

for reaction 2, and for reaction 3

$$R_3 = (n_D n_T\ \text{cm.}^6)\ 10^{-17}\ \text{cm.}^{-3}\ \text{sec.}^{-1}\int_0^\infty \varphi_{DT}(E)\ \mathrm{d}\,(E/\text{keV.}) \quad (10)$$

with

$$\varphi(E)_{DT} = 1{\cdot}622(kT/\text{keV.})^{-2/3}\ \exp(-0{\cdot}5996\ E/kT)\ (\sigma_3(E)E/\text{barn/keV.})$$

where all quantities are expressed in terms of the units indicated.

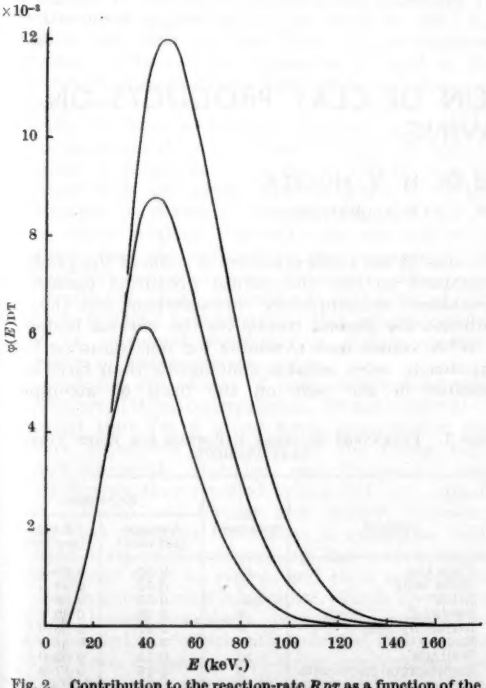

Fig. 2. Contribution to the reaction-rate R_{DT} as a function of the deuteron energy E for kT = (left to right) 6, 7, 8 keV.

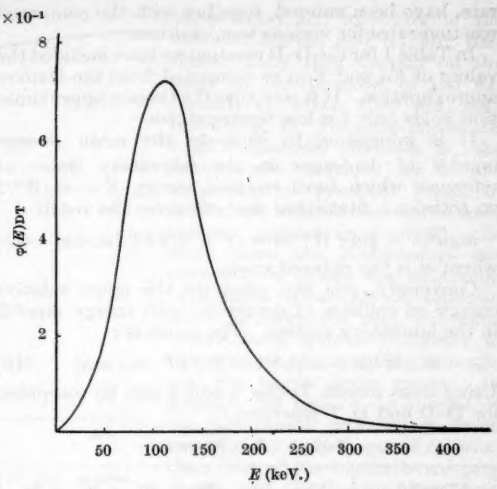

Fig. 3. φ_{DT} as a function of E for kT = 40 keV.

Fig. 1 shows φ_{DD} for temperatures of 10–60 keV. in steps of 10 keV. Fig. 2 shows φ_{DT} for temperatures of 6, 7 and 8 keV. Fig. 3 shows φ_{DT} for a temperature of 40 keV. It is seen that the reaction-rate is in each case mainly due to particles belonging to the tail of the Maxwell distribution. The total reaction-rates were computed in accordance with formulæ (9), (10) by integration over dE.

An approximation to the reaction-rate can be obtained by means of a method due to Gamov. One can write, in first approximation:

$$\int_0^\infty \varphi(E)\mathrm{d}E = \Delta E\varphi(E_m) \quad (11)$$

because the integrand is of the form

$$\varphi(E) = \exp\{-(mE/m_A kT) - B'E^{-1/2}\} \quad (12)$$

and has a sharp maximum as a function of E at $E = E_m = (B'm_A kT/2m)^{2/3}$. If ΔE is defined by:

$$\varphi(E + \Delta E/2) = \varphi(E_m)/e \quad (13)$$

ΔE is given by:

$$\Delta E = (32/3\ B')^{1/2}\ (B'm_A kT/2m)^{5/6} \quad (14)$$

In the results for the DD and DT reaction-rates which have been tabulated below, the values for E_m, the energy of the maximum contribution to the reaction-

Table 1. R_{DD} IN UNITS OF 10^{-18} CM.$^{-3}$SEC.$^{-1}$ ($n_D$cm.^{3})^2

kT	E_m (Gamov)	E_m	R_{DD} (Gamov)	R_{DD}	Per cent effective
10 keV.	59 keV.	59 keV.	0·60	0·98	11
20	94	104	2·38	3·40	16
30	124	124	4·45	6·75	24
40	150	134	6·46	10·11	34·2
50	174	185	8·33	13·87	29·6
60	196	225	10·03	17·96	29·7

Table 2. R_{DT} IN UNITS OF 10^{-18} ($n_D n_T$ cm.^{6}) CM.$^{-3}$ SEC.$^{-1}$

kT	E_m	R_{DT}	Per cent effective
2 keV.	19·8 keV.	0·263	0·71
4	31·6	5·91	2·3
6	40·6	25·71	4·27
7	44·4	40·27	5·4
8	48	60·51	6·52
40	110	748	25

rate, have been entered, together with the computed reaction-rates for various temperatures.

In Table 1 for the D–D reaction we have included the values of E_m and R_{DD} as computed from the Gamov approximation. It is seen that the Gamov approximation holds only for low temperatures.

It is interesting to compute the mean energy $m_D\overline{u^2}/2$ of deuterons in the laboratory frame of reference which have relative energy $E = m_D W^2/2$ on collision. Statistical analysis gives the result :

$$m_A\overline{u^2}/2 = \tfrac{1}{2}m_A W^2 (m/m_A)^2 + 3/2\, kT\, (m/m_B) \quad (15)$$

where m is the reduced mass.

Conversely, one can compute the mean relative energy on collision of deuterons with energy $m_Du^2/2$ in the laboratory system. The result is :

$$m_A \overline{W^2}/2 = m_A u^2/2 + 3/2\, kT\, (m_A/m_B) \quad (16)$$

Using these results Tables 3 and 4 can be computed for D–D and D–T reactions :

Table 3. D–D Reactions

kT (keV.)	10	20	30	40	50	60
E_m (keV.)	59	94	124	150	174	196
$m_D\overline{u^2}/2$ (keV.)	22	39	54	68	81	94
$m_Du^2/2$ (keV.)	44	64	79	90	99	106

Table 4. D–T Reactions

kT (keV.)	2	4	6	7	8	40
E_m (keV.)	19·8	31·6	40·6	44·4	48·0	110
$m_D\overline{u^2}/2$ (keV.)	8·35	14·1	18·2	20·2	22·1	63·8
$m_Du^2/2$ (keV.)	17·8	27·6	34·6	37·4	40	70

The energies $m_Du^2/2$ have been computed from equation (16), where $m_A\overline{W^2}/2$ has been identified with E_m. They are thus the energies of deuterons which have a mean relative energy equal to the relative energy giving the maximum contribution to the reaction rate.

In Tables 1 and 2 there are columns headed 'per cent effective'. These are the percentages $\Delta n_A/n_A \cdot 100$ of deuterons with relative energy larger than E_m computed from :

$$\Delta n_A/n_A = n_B\, 4/\sqrt{\pi} \int_Z^\infty z^2 \exp(-z^2)\, dz$$

where the lower limit of the integral is given by $Z = (mW^2/2)^{1/2}$ and m is again the reduced mass.

Looking at these tables one notes that ions with fairly low energies in the laboratory system have on average a high relative energy. This may be relevant when one is considering the effect on the reaction-rate of accelerated deuterons inserted into a discharge. Looking at Table 2 one notes that in the case of the D–T reaction the effective percentages are rather low, again showing that relatively few accelerated deuterons injected into a plasma may produce reaction-rates comparable to the purely thermonuclear ones. A complete discussion of these effects would, of course, have to include acceleration processes and energy loss of extra particles. Such studies are being undertaken at Oxford.

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PERMANENT MOISTURE EXPANSION OF CLAY PRODUCTS ON AUTOCLAVING

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In the course of a study of the permanent moisture expansion of clay products we have found that all such products so far examined expand once they leave the kiln and are exposed to the action of water or water vapour. We have also found that reproducible maximum or total expansions, usually many times greater than expansions so far reported, are obtained by autoclaving the kiln-fresh samples in saturated steam at elevated temperatures until stable dimensions have been attained, the actual temperature of autoclaving being unimportant. About 400 industrial and laboratory specimens have now been autoclaved for 24-hr. periods at 200° C. (225 lb./sq. in. absolute) until expansion ceased, and the average and range of the total moisture expansions (measured after drying for 48 hr. at 110° C.) for eight types of product are given in Table 1; curves for the average expansion with time for each of these products are given in Fig. 1, and the curves for two individual bricks, one light-burnt the other hard-burnt from the same kiln sampling, in Fig. 2. Because of the small numbers of some of the products examined so far, the values presented cannot be considered as completely characteristic, but they do indicate the general trends for the various bodies.

With values now available for maximum or total expansion, more reliable conclusions than have been possible in the past on the basis of incomplete

Table 1. Permanent Moisture Expansion for Eight Types of Clay Products

Product	No. examined	Expansion	
		Average (per cent)	Range (per cent)
Floor tile	12	0·50	0·60–0·32
China body	6	0·39	0·44–0·34
Brick	220	0·35	0·85–0·16
Firebrick	6	0·28	0·29–0·26
Refractory body	6	0·27	0·28–0·26
Roofing tile	89	0·25	0·42–0·13
Wall tile	10	0·19	0·23–0·17
Architectural terra-cotta	6	0·16	0·17–0·14

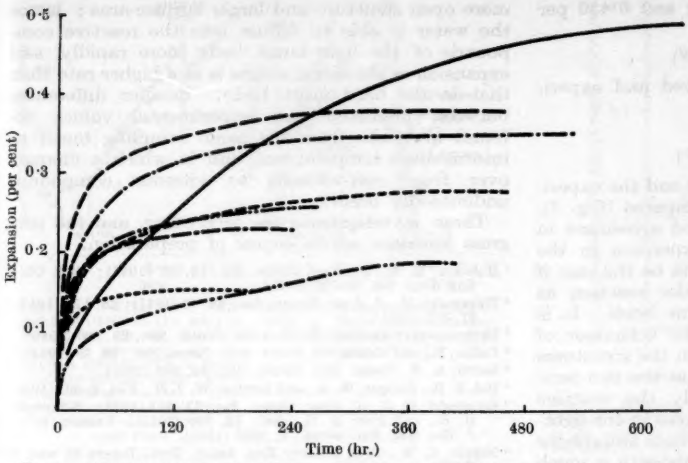

Fig. 1. Average permanent moisture expansion for eight types of clay product. ····, Architectural terra-cotta; ·—·—·, wall tile; ——, floor tile; – – –, china body; —·—, brick; ·—·—·, firebrick; ·—··—·, refractory body; ·———·, roofing tile

expansions may be drawn as to the influence of such factors as the temperature of the moisture to which they are exposed, raw materials or body composition, methods of manufacture and firing temperature on the rate and extent of the expansion of various bodies.

That the rate of expansion of ceramic bodies varies with the temperature of the moisture to which they are exposed has been observed by many workers[1–6]. This has not only been confirmed by the present work, but by recalculating our figures and those of Mattyasovszky-Zsolnay[3], Bullin and Green[4] and Smith[5] to the hours of treatment necessary to give the same expansions in one hour at 200° C., we have been able to show that the temperature coefficient of the rate of expansion, at least in the early stages, is similar for a wide range of bodies and temperatures of reaction. For ceramic bodies generally the average rate of expansion is shown to change approximately 1·8 times for each 10 deg. C. variation in temperature, a figure which may be compared with the usual value of about 2 for the temperature coefficient of chemical reaction.

The above workers believed that the extent of expansion was also affected by the temperature of the moisture, but since none of their measurements was continued until dimensional stability of the body was reached, it is now clear that what appeared to be an increased expansion is merely another expression of increased rate.

In studying the effects of body composition and temperature of firing on expansion, certain workers[1,2,7] concluded that for a given body composition the moisture expansion decreased as the firing temperature increased. Holscher[1] and Thiemecke[2] considered further that vitrified bodies did not expand at all. Bullin and Green[4] and Norris[8], however, showed that apparent reductions in expansion with increased firing temperatures were due to reductions in rate rather than in extent, and their conclusions are more in accord with our results. These show that while all bodies examined, including well-vitrified ones, expanded on contact with moisture, the relationships between expansion and firing temperature are most complex and cannot be expressed in general terms. The relationships vary according to the composition and structure of the different bodies, and for any particular body they depend on the stage in the progress of the expansion at which they are compared (Fig. 2). For some bodies the total expansion increases as the temperature increases up to the maximum of practical firing, in which case well-vitrified and bloated samples expand most of all. In some cases the relationships are reversed, in others the maximum expansions occur at an intermediate temperature, and for some bodies there is little difference in the amount of expansion throughout the whole firing range. In general, the rate of expansions of the light-burnt products is much faster in the early stages of reaction than that of the harder-burnt products, and the lighter-burnt products reach their total expansion in a shorter time.

A study of the expansion curves for many well-burnt products shows that the relationships between expansion and time may be expressed by the equation:

$$E_t = E_T\,(1 - e^{-kt})$$

in which E_t per cent is the expansion at any time t hours, E_T per cent is the total expansion, and k is a constant. Such an equation is similar to that for a first-order chemical reaction in which E_T is a function of the concentration of the components which on hydration give rise to expansion, E_t depends on the amount of material hydrated in time t, and k is the velocity constant. Hence, the reactions responsible for expansion obey first-order kinetics. For the hard-burnt brick the expansion of which is illustrated in Fig. 2, the derived equation, in which t

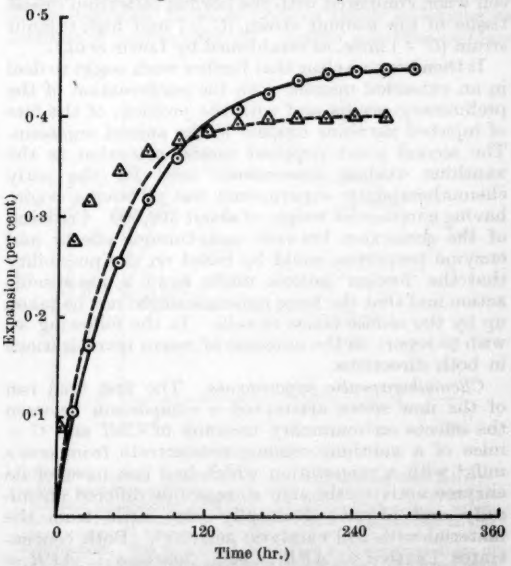

Fig. 2. Experimental and derived permanent moisture expansion for a light-burnt and a hard-burnt brick from the one kiln sampling. Hard-burnt: ⊙, experimental; ——, derived values. Light-burnt: △, experimental; – – –, derived values

is expressed in hours of autoclaving and 0·450 per cent is the total expansion, is :

$$E = 0{\cdot}450\ (1 - e^{-0{\cdot}018t})$$

and the good fit between the derived and experimental values is apparent.

When the similar equation :

$$E = 0{\cdot}403\ (1 - e^{0{\cdot}026t})$$

is applied for the light-burnt product and the experimental and calculated values are compared (Fig. 2), it is seen that although there is good agreement in the later stages of the reaction, expansion in the early stages is much faster than would be the case if the curve followed a simple first-order reaction as closely as does that of the well-burnt brick. It is considered that this difference in the behaviour of the two bricks is due to differences in the structures of the reactive compounds produced at the two temperatures. In the well-burnt body the reactive compounds are probably glassy, whereas in the light-burnt one they are probably non-vitreous amorphous silicates and dehydrated clay minerals with a much more open structure and larger surface-area ; hence the water is able to diffuse into the reactive compounds of the light-burnt body more rapidly, and expansion in the initial stages is at a higher rate than that in the hard-burnt body. Smaller differences between predicted and experimental values are found in bricks from the same sampling burnt at intermediate temperatures, and in which a change-over from non-vitreous to vitreous compounds undoubtedly occurs.

These investigations are proceeding, and full progress accounts are in course of preparation.

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ANTI-TUMOUR AND BIOCHEMICAL EFFECTS OF PURIFIED BOVINE XANTHINE OXIDASE IN *C3H* AND *C* MICE

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THE observation[1] that xanthine oxidase inhibits the growth of spontaneous mammary carcinoma in mice carrying the Bittner factor was discussed at a Ciba Foundation Symposium[2] in relation to the lower levels of the activity of this enzyme in the tumour cell when compared with the normal cells from breast tissue of low-tumour strain (*C* −) and high-tumour strain (*C* +) mice, as established by Lewin *et al.*[3].

It then became clear that further work ought to deal in an extended manner with the confirmation of the preliminary results and with the problem of the fate of injected xanthine oxidase in the animal organism. The second point required special attention as the xanthine oxidase concentrate used for the early chemotherapeutic experiments was of bovine origin, having a molecular weight of about 300,000. Criticism of the connexion between anti-tumour effects and enzyme properties could be based on the possibility that the 'foreign' protein might exert a non-specific action and that the large molecule might not be taken up by the mouse tissue or cells. In the following we wish to report on the outcome of recent investigations in both directions.

Chemotherapeutic experiments. The first trial run of the new series attempted a comparison between the effects on mammary tumours of *C3H* and *C* + mice of a xanthine oxidase concentrate from cow's milk[4] with a preparation which had lost most of its enzyme activity through storage but differed chemically and physico-chemically very little from the material with full catalytic activity[5]. Both concentrates ('active' : *AFR* = 90 ; 'inactive' : *AFR* = 6) were injected intraperitoneally twice daily using 10 mgm. doses of xanthine oxidase in 1 ml. saline, together with 0·2 mgm. of sodium salicylate. (Specific activities are expressed as *AFR* values[4] ; all the samples used in this and subsequent experiments had E_{280}/E_{450} (that is, *PFR*) values of about 7–8 ; weights of xanthine oxidase are calculated from E_{450} values[5].) Sodium salicylate had been found to stabilize the active enzyme considerably[6]. Perhaps because of the presence of salicylate, which is also an inhibitor of xanthine oxidase, the growth-rates of the tumours (measured in two perpendicular directions and expressed as surface area) were not slowed down very distinctly, though the impression was gained that in the mice treated with the active enzyme preparation the over-all effect was somewhat larger.

The next trial was carried out with active concentrates which were prepared following a differen-sequence of purification steps than for previout batches. The procedure, in some respects similar to that of Klenow and Emberland[7], consisted of treatment with butanol, ammonium sulphate fractions ation and calcium phosphate chromatography after enzymic digestion of buttermilk. In view of the above-mentioned difficulties the material containing salicylate was dialysed against sodium chloride and thus freed from the stabilizer-inhibitor a short time before use. The solutions had *AFR* values of 50–100, and 5 mgm. doses in 1 ml. of saline were injected daily intraperitoneally. A group of 18 tumour-bearing *C* + and *C3H* mice and an equally large control group which received saline injections were used. The results are graphically represented in Figs. 1*A* and *B*. Fig. 1*A* shows the mean relative tumour

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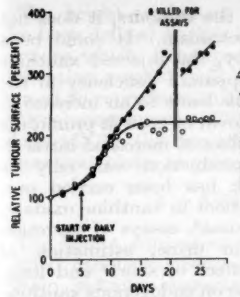

Fig. 1A. Experiment with eighteen *C3H* and *C* + mice in each group. ●—●, Controls on saline injection; ○—○, animals treated with 5 mgm. xanthine oxidase daily. Relative tumour surface = (surface of tumours at each day × 100/surface of tumours at time zero)

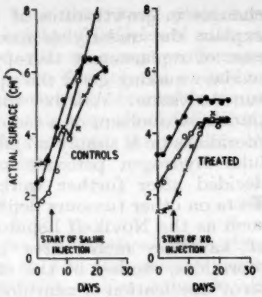

Fig. 1B. Actual tumour surface area of three representative individual animals from each group of Fig. 1A

surface for the respective groups, and Fig. 1*B* gives the actual surface values (cm.²) of representative individual animals. Although the growth-rate of the tumours was variable a definite inhibitory action of the enzyme preparation could be observed. It is noteworthy that on cessation of the xanthine oxidase injections the tumours which had been arrested appeared to regain growth-rates similar to those of the controls, results which are not given in Figs. 1*A* or *B*.

Biochemical experiments. It was pointed out at the beginning that it was important to establish beyond doubt the accumulation of the extraneously introduced enzyme in measurable amounts in the organs of the mice. For this purpose the fate of injected milk xanthine oxidase was followed by quantitative assay in three ways. The levels of activity were estimated[3] in the intraperitoneal cavity and in the liver of *C* − mice after intraperitoneal injection of xanthine oxidase. An 'inactive' enzyme concentrate, bovine plasma albumin (Armour), 'supernatant' solutions from thermal denaturation of the enzyme and albumin and supernatant together were also studied. (The 'inactive' sample was prepared from a portion of the active one by irradiating with a tungsten lamp for 13 hr. The solution was immersed in a bath at 37° C. and stirred gently in an open vessel during irradiation. Water was added to make good the evaporation, and a slight precipitate was centrifuged off. The 'supernatant' solution was prepared by immersing a portion of the active enzyme

Table 1. Effect of Injections on Levels of Xanthine Oxidase Activity in Peritoneal Cavity and in Liver. Enzyme Activity:

Time after injection (hr.)	Intraperitoneal cavity			Liver		
	Intraperitoneal washings: 10^3 units (ref. 4)		Per cent of injected dose	Total liver homogenate: 10^3 units (ref. 4)		Per cent of injected dose
	Controls	Treated		Controls	Treated	
4	0	1·76	1·4	2·05	7·68	6·1
6	0	1·24	1·0	2·28	7·77	6·2
24	0	0·05	0·04	2·31	7·62	6·0

The treated *C* − mice received 5 mgm. (0·126 unit, ref. 4) of xanthine oxidase intraperitoneally. At the time of death, 2 ml. of 0·15 *M* sodium chloride were injected intraperitoneally to wash the cavity. The mice were massaged and then 1 ml. of the injected liquid was taken out. Determinations of xanthine oxidase were carried out on this liquid and on the excised livers. The controls were treated similarly with 0·15 *M* sodium chloride. All values are the mean of two determinations.

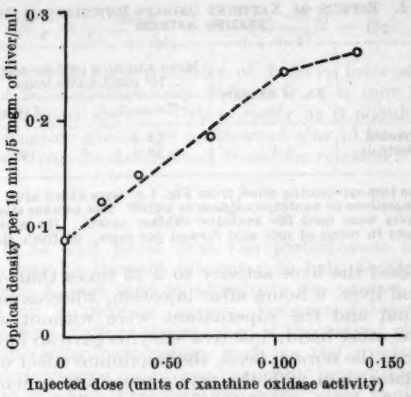

Fig. 2. Relation between liver xanthine oxidase activity and injected dose (in 2 ml. saline) 4 hr. after injection. The first point is the mean of determination on twelve *C* − mouse livers and the others of two. The livers were thoroughly washed in pyrophosphate buffer before homogenization

solution in a boiling water-bath for 5 min. with protection from light and then decanting the clear solution.) Finally, the xanthine oxidase activity was measured in the tumour tissue and livers of treated and control *C3H* and *C* + animals.

As can be seen from Table 1, washings of the intraperitoneal cavity still contained a measurable amount of the injected xanthine oxidase after four hours, this quantity falling to zero after 24 hours. An assay of the liver of the same animals indicated a substantial rise in the level of enzyme activity over the controls. It was then decided to test different amounts of xanthine oxidase to see whether the increase in the liver depended on the quantity of enzyme injected. As Fig. 2 shows clearly, the increase of xanthine oxidase activity in the liver is practically proportional to the dose up to about 0·1 unit, at which value the curve begins to level off. In another experiment the effects of the enzyme were compared with those of various other injections as mentioned before (Fig. 3). Active xanthine oxidase

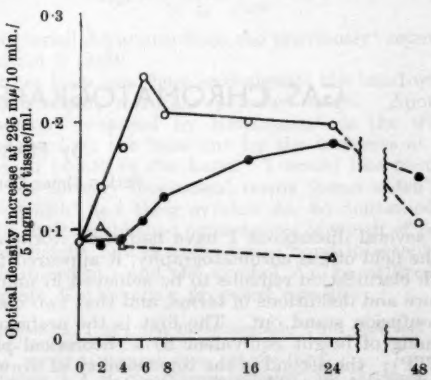

Fig. 3. Effect of injections on liver xanthine oxidase activity. Active xanthine oxidase: *AFR* = 95; 5 mgm. in 1 ml. saline. 'Inactive' concentrate *AFR* = 4; 5 mgm. in 1 ml. saline. Supernatant from equivalent of 5 mgm. enzyme. Crystallized bovine plasma albumin (Armour) 10 mgm. in 1 ml. saline or in 1 ml. of supernatant. The first point is the mean of determinations of twelve *C* − mouse livers and the others of three. The livers were thoroughly washed in pyrophosphate buffer before homogenization. ○—○, Active xanthine oxidase; ●—●, 'inactive' xanthine oxidase; ◁—△, albumin, supernatant or both

Table 2. Effects of Xanthine Oxidase Injections on Tumour-bearing Animals

	No. of animals	Mean xanthine oxidase activity 10^4 μmoles/min./mgm.	
		Tumour	Liver
Treated	4	24·4	40·0
Controls	6	10·0	14·3

Some tumour-bearing mice, from Fig. 1*A*, were killed after fifteen daily injections of xanthine oxidase or saline. The tumour tissue and the livers were used for xanthine oxidase assays; the activity is expressed in terms of uric acid formed per mgm. of fresh tissue.

increased the liver activity to 2·75 times that of the normal liver, 6 hours after injection, whereas bovine albumin and the supernatant were without effect. On the other hand, 'inactive' enzyme gave an increase to twice the normal level, the maximum effect occurring later than with the active preparation, namely, about 24 hours after the injection. This time-lag suggests that the inactive material is reactivated in the tissues of the mice.

Finally, Table 2 shows that in treated *C3H* and *C* + animals bearing tumours, not only the livers but also the tumour itself shows a higher xanthine oxidase activity-level than in the controls.

Conclusions and further outlook. From the results, just reported, it can be concluded that xanthine oxidase, even from a different species, can hold up the growth of spontaneous mammary tumours in *C3H* and *C* + mice. This is accompanied by an increase of the activity levels of xanthine oxidase in the livers and tumours of the treated animals. In experiments with *C* − animals it could also be demonstrated that the bovine enzyme causes an increase of the xanthine oxidase of liver, the levels being dependent on the amounts injected. 'Inactive' enzyme preparation was apparently reactivated in the liver but gave less rise than the concentrate with full enzymic activity. On the other hand, neither the 'supernatant' fraction nor bovine albumin or a combination of both produced any effects. While all this suggests strongly that the active xanthine oxidase molecules penetrate into the liver and tumour of the animals, and explains to some extent the observed changes in growth-rates of the tumours, it does not explain the underlying mechanism. It could be a case of replacement therapy, the injected xanthine oxidase making good the apparent deficiency in the tumour tissue. Whether this leads to an increase in purine catabolism, or a removal of growth-promoting pteridines or is simply an effect of increased intracellular hydrogen peroxide production, can only be decided after further work has been carried out. Tests on other tumours deficient in xanthine oxidase, such as the Novikoff hepatoma[8], assays of excretion of xanthine metabolites in urine, estimation of pteridines, studies of the effect of short[9] and long-term[3] application of xanthine on endogenous xanthine oxidase, could help in finding out more about our results. Only then could one think of extending the chemotherapeutic investigation to include combinations of xanthine oxidase with other related enzymes or with drugs, and to attempt, after immunological and pharmacological tests, corresponding trials in human patients.

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GAS CHROMATOGRAPHIC TERMS AND DEFINITIONS

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IN several discussions I have had with workers in the field of gas chromatography, it appeared that much clarification remains to be achieved in nomenclature and definitions of terms, and that two causes of confusion stand out. The first is the ambiguous meaning of height equivalent to a theoretical plate (HETP); the second is the impossibility of drawing precise conclusions about the resolution (or resolving power) of a chromatographic column from a knowledge of the number of theoretical plates of that column, regardless of which of the two available definitions of the height equivalent to a theoretical plate is adopted. Both causes of confusion lose relevance when the retention-time of sample components, t, becomes very large when compared with the retention-time of inert gas packets, t_a, but the validity and usefulness of a system of terms and definitions should extend to those cases where t is no longer very large when compared to t_a.

The height equivalent to a theoretical plate has been defined[1] as that height of individual column portions which, if lumped into as many separate funnels of a Craig's machine, will cause the column so transformed to reproduce, in theory, the observable times t, t_a and Δt of the elution curves. When Δt designates the 'band-width at mid-height', the definition given leads to the following number of theoretical plates in a column[2]:

$$n_0 = 8 \ln 2 \frac{t(t - t_a)}{(\Delta t)^2} = 5{\cdot}54 \frac{t(t - t_a)}{(\Delta t)^2} \qquad (1)$$

The height equivalent to a theoretical plate has also been defined as that height of individual column portions which, if lumped into as many continuous absorption vessels[3], will cause the column so transformed to reproduce, in theory, the observable times of the elution curves. With this more usual definition, which will be the one adopted here, the number of theoretical plates is given by:

$$n = 5{\cdot}54\,\frac{t^2}{(\Delta t)^2} \qquad (2)$$

The height equivalent to a theoretical plate thus defined can be connected in a simple manner with certain column characteristics. For example, if tu(cm.^{2}) designates the second moment, with respect to the column abscissa x, of a component distribution of total mass normalized to unity, the height equivalent to a theoretical plate (cm.) represents the increase of this second moment as the component packet travels 1 cm. in the column:

$$\mathrm{HETP} = \frac{\mathrm{d}u}{\mathrm{d}x} \qquad (3)$$

If the column consists of a capillary tube, uniformly coated with a retentive layer within which diffusion time is negligibly small, the following equation can be derived for the quantity above[4]:

$$\frac{\mathrm{d}u}{\mathrm{d}x} = 2\,\frac{D}{v_0} + \frac{1 + 6k + 11k^2}{24(1+k)^2}\,\frac{v_0\,r_0^2}{D} \qquad (4)$$

where D(cm.^{2} sec.$^{-1}$) is the rate of diffusion of component molecules in carrier gas; v_0 (cm. sec.$^{-1}$) is the average speed of carrier gas; and $k = (t - t_a)/t_a$ is the ratio of fixed phase capacity to moving phase capacity for the component; while r_0 (cm.) is the radius of the capillary.

It should be particularly noted that the very simple first term of the right-hand side of equation (4) represents the static diffusion term and corresponds to the second term of van Deemter's equation[5]. No other definition of the height equivalent to a theoretical plate can lead to a term in D/v_0 as simple as the one above, which should always be found (with a tortuosity factor γ for packed columns) in any theoretical expression purporting to connect the height equivalent to a theoretical plate with physical column parameters.

But the real measure of a column's efficiency is the resolution or resolving power of this column, that is, the potential ability of the column to separate two substances which differ but little in their affinity for the fixed (liquid or solid) phase. This resolution will be defined here as the inverse of the 'relative band-width', $\Delta t/(t - t_a)$:

$$R = \frac{t - t_a}{\Delta t} = \frac{k}{1 + k}\,\frac{t}{\Delta t} \qquad (5)$$

When R is known for a given column and for one of a given pair of closely similar components, the 'relative separation', S_{12}, achievable for these components—the ratio of their actual time separation in the elution curve, Δt_{12}, over the band-width of one or the other, Δt_1 or Δt_2—will be immediately calculable from R and from the ratio of the partition coefficients, C_1 and C_2, of these components for the fixed phase, this ratio being a dimensionless physical quantity depending solely upon the nature of the two components and of the fixed phase, and not upon any design parameter of the column. Let ε designate the Naperian logarithm of the C_2/C_1 ratio. We have, with very good approximation:

$$S_{12} = \frac{2\Delta t_{12}}{\Delta t_1 + \Delta t_2} = R\,\frac{2(C_2 - C_1)}{C_2 + C_1} = R\varepsilon \qquad (6)$$

It is noted that the quantity of decisive interest, R, cannot be unambiguously derived from n (nor from n_0) as defined above. This is really as it should be, for a decision about the optimum k should be made, before R can be determined from the relation:

$$R = \frac{k}{1 + k}\,\sqrt{\frac{n}{5{\cdot}54}} \qquad (7)$$

It is at this point that the performance index (P.I.) may be brought into play to help decide the optimum k, and thus to constitute the needed link, based on a physical theory, between fabricating parameters, such as the number of theoretical plates, and operating parameters, such as the resolution. The performance index was originally introduced[6] as a quantity which is nearly invariant in 'ideal' capillary columns (namely, columns in which the diffusion-time in the fixed phase is negligibly small), operated at the optimum flow-rate, and which could serve as a measure of the intrinsic goodness of a column. Since the publication of the original communication[6], a more rigorous theoretical treatment of capillary columns has been made, and this led to the slightly modified definition given below, in which the factor 15/16 has been substituted for the former factor 3/4[7]:

$$\mathrm{P.I.} = \frac{(\Delta t)^4\,t_a\,\Delta p}{t^3(t - 15t_a/16)} \qquad (8)$$

where Δp designates the drop in pressure across the column. When the performance index is written as follows:

$$\mathrm{P.I.} = \left(\frac{\Delta t}{t - t_a}\right)^4 \cdot \frac{(t - t_a)^4\,t_a}{t^4\,(t - 15t_a/16)} \cdot t\Delta p \qquad (9)$$

the first factor of the right-hand side is recognized as $1/R^4$ and should therefore be minimized, and if the last factor, $t\Delta p$, constitutes a pre-assigned experimental boundary condition, then optimum performance will be obtained for the value of k which maximizes the middle term:

$$k_{\mathrm{opt}} = \left(\frac{t - t_a}{t_a}\right)_{\mathrm{opt}} = 3{\cdot}1 \qquad (10)$$

a very small departure from the previously[6] reported optimum k (3·3).

Δt has been used here to designate the band-width at mid-height, a rather popular usage. Another parameter, proposed by Keulemans[8], is the width intercepted on the base line by the tangents at the inflexion points of the band. I would like to urge that the already much-used terms 'band-width', or 'peak-width' and their symbol Δt, be continued in use in their established connotation of width of band at mid-height, and that the term 'band intercept' or 'peak intercept', and the symbol $\Delta_i t$, be utilized to designate Keulemans's proposed measure.

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LETTERS TO THE EDITORS

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A New Phenomenon of Electron Emission from Thin Mercury Films

When describing a new power rectifier valve utilizing line emission from the wetting edge of a mercury pool[1], the observation of a new phenomenon of emission was mentioned. At low loads, luminous patches had appeared for short instants parallel to the emission line in places on the anchor where film-like condensation had occurred. The luminous patches started on the film of condensate without visible initiation by a cathode spot from the emission line.

Emission into a mercury vapour arc from an extended area is in striking contradiction to the present concept of emission from liquid surfaces; hence, reproduction of the observed phenomenon over periods of sufficient length of time for proper observation promised a new way of approach to the mechanism of emission from liquid surfaces; further, it could yield valuable improvements for power rectifiers.

After more than three years of technological difficulties, a system satisfying stringent high-vacuum conditions has been produced. Fig. 1 shows its critical part under operating conditions. The emission system consists of a well-defined molybdenum surface (A) of about 1 cm.^{2} where the temperature can be adjusted at will between 20° and 70° C. This is enclosed in a discharge vessel with several electrodes and a reservoir, filled with about 1·5 cm.^{3} of liquid mercury. The walls of the discharge vessel, except the cathode surface A, are kept at a uniform temperature, variable between 20° and 350° C. Inflow of vapour towards the cathode system is thus determined by the temperature of the cathode and the vessel; excess condensate, if building up, returns in droplets to the reservoir. A protective conical screen (B) of thin molybdenum sheet extends from the temperature-controlled area down into the mercury reservoir, and prevents damage to the glass seal by the discharge. The discharge current covered the range 1–30 amp.

Fig. 1

A number of different phases of the emission, largely varying in appearance according to the specific operating conditions chosen, have been obtained, and also maintained for any desired length of time. These phases are: (i) the well-known free spots, running at random around on the spare mercury and the condensate droplets on surface A and cone B; (ii) transitional stages, consisting simultaneously of spots and fragments of lines moving at random with a preference for surface A; (iii) a multitude of streamers, emanating from the border between A and B, mostly extending on to A, but eventually also leading downwards on B, either alone or in combination with (ii); (iv) a uniform and steady glow-like thin sheath of small luminosity, evenly covering and clearly restricted to the surface part A, a phase for which the term 'film emission' will be used in the following.

The case shown in Fig. 1 is a transitional stage consisting of a short emission line (c), a number of streamers (d) and a patch of film emission (e); total emission current was 23 amp.; f is the ignition needle and g indicates large droplets of condensate.

Film emission, exclusively, can be obtained over a wide range of current densities; at very low values or with insufficient vapour density at the emission surface, the even spreading ceases, and contraction to lines, streamers or spots takes place. This behaviour suggests that the steady low current-density form of emission without evaporation represents the true and simple emission mechanism, while the more complex phases with random motion appear to be the unsuccessful attempts of the true mechanism to create those operative conditions which are required for the most favourable emission conditions.

It is too early to advance a theory of film emission. So far as observations go, they could be equally well interpreted by a current at the cathode composed overwhelmingly of electrons, or half of ions and half of electrons. In the first case the emission mechanism is a greater mystery than ever, because the current densities are several orders of magnitude too low for the mechanisms so far proposed. In the second case, one would have to postulate the release of about one electron per ion at the cathode surface, and a rather surprisingly efficient ionization mechanism in the region of cathode drop, which produces about one ion pair per electron. It is hoped that this will be decided directly by experiments now planned.

Because the film emission occurs at a definite place and is restricted to well-determined areas, clarification of the many rather conjectural assumptions made in the present theories of spot emission may be expected. One conclusion can be made already with certainty, namely, that emission from surfaces of liquid metal does not require intrinsically current densities of the order of thousands or ten thousands of amperes per square centimetre; neither does it require evaporation of the metal. For the further study of the emission of liquid surfaces, theories based on high current densities and evaporation of cathode material thus cannot claim universal validity.

My thanks are due to Prof. D. Gabor for putting at my disposal the resources of his laboratories at the

Imperial College of Science and Technology, London, and for his constant encouragement.

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Elastic Constants of Diamond

IN a recent communication in *Nature*, Krishnan, Chandrasekharan and Rajagopal[1] suggest that discrepancies between the determinations of the elastic constants of diamond may find an explanation in the enlarged scheme of elastic constants suggested by Laval, LeCorre, Viswanathan and Raman. In referring to the results of the experiments by Prince and Wooster[2], they suggest that "probably the theory of diffuse scattering of X-rays needs some modification in the light of the new theory of elasticity".

In the following communication, we indicate what changes the new theory of elasticity introduces into the interpretation of the measurements of Prince and Wooster, with the same notation as used in their paper, and using for the new theory the notation of the Indian school (which differs from the one originally introduced by Laval in that their d_{45} is his N_{47}, etc.). The change introduced by the new theory consists in the coupling together of d_{12} and d_{45} to form an inseparable pair of constants. For example, the experiments on a 110 reflexion enable the intensities of diffuse scattering from points along the [110] and [001] directions to be compared. The corresponding K-ratio, $K[110]_{220}/K[001]_{220}$, is in the old theory: $2c_{44}/(c_{11} + c_{12} + 2c_{44})$, and in the new theory: $2d_{44}/\{d_{11} + d_{44} + (d_{12} + d_{45})\}$. Similar changes are introduced into the other K-ratios.

On the old theory the following ratios for the elastic constants were found:

$$c_{12}/c_{11} = 0{\cdot}30 \pm 0{\cdot}02, \quad c_{44}/c_{11} = 0{\cdot}40 \pm 0{\cdot}02$$

We repeated the calculations using this time the formulæ of the new theory, and obtained for the new ratios:

$$(d_{12}+d_{45})/d_{11} = 0{\cdot}70 \pm 0{\cdot}02, \quad d_{44}/d_{11} = 0{\cdot}40 \pm 0{\cdot}02$$

The absolute value of the constant d_{44} was measured by Prince and Wooster using the intensity of Compton scattering as the standard. This gave a value of $(44 \pm 2{\cdot}5) \times 10^{11}$ dyn. cm.$^{-2}$. (These units will be used throughout this communication.) Using the above ratio for d_{44}/d_{11}, the value:

$$d_{11} = 110 \pm 11$$

is obtained. To proceed further, it is necessary to consider the bulk modulus of elasticity. The bulk modulus, k, is connected with the elastic constants by the equation:

$$k = (d_{11} + 2d_{12})/3$$

The value of k given by Adams[3] is 63, and by Williamson[4], 56. They lead to the following values of d_{12}:

$$\begin{aligned} d_{12} &= 39 \pm 6 \text{ (Adams)} \\ &= 29 \pm 6 \text{ (Williamson)} \end{aligned}$$

Now, $d_{12} + d_{45} = (0{\cdot}70 \pm 0{\cdot}02)d_{11} = 77 \pm 10$, and hence:

$$\begin{aligned} d_{45} &= 38 \pm 16 \text{ (Adams)} \\ &= 48 \pm 16 \text{ (Williamson)} \end{aligned}$$

Table 1 summarizes the results calculated according to the two theories:

Table 1

Old theory	New theory (with Adams's k)	(with Williamson's k)
$c_{11} = 110 \pm 11$	$d_{11} = 110 \pm 11$	110 ± 11
$c_{12} = 33 \pm 5$	$d_{12} = 39 \pm 6$	29 ± 6
$c_{44} = 44 \pm 2{\cdot}5$	$d_{44} = 44 \pm 2{\cdot}5$	$44 \pm 2{\cdot}5$
	$d_{45} = 38 \pm 16$	48 ± 16

Unfortunately, the uncertainty in the diffuse X-ray measurements, combined with the uncertainty in the measurement of the compressibility, make it impossible to establish a significant numerical difference between d_{44} and d_{45}. The same uncertainty in the compressibility affects all the calculations of d_{45} based on the dynamically measured $(d_{12} + d_{45})$. Consequently it is hard to see how any experimental proof can at this stage be given that the classical three elastic constants are insufficient for diamond, and that the four constants of the new theory have to be applied to it.

Quite apart from these experimental considerations, we have suggested in a recent communication[5] that in those cases where the Laval theory is applicable the number of independent elastic constants is not 45 but 39. For the Laue-group $m3m$, to which diamond belongs, the number of independent elastic constants turns out to be three, the same as in the classical theory.

Furthermore, it is difficult to accept the view that a separation of the results of methods that are all essentially dynamic, into 'static constants' and 'wave (dynamic) constants', can be made in the way suggested in the communication by Krishnan *et al.*[1].

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Errors in the Measurement of Film Thickness by Multiple-Beam Interferometry

THE Tolansky[1] method for the measurement of the thickness of thin films by multiple-beam interference techniques is now well established. Briefly, the film, the thickness of which is to be measured, is deposited on a flat, smooth substrate. The film should have a sharp edge so that a step is formed when the film and the adjacent substrate are coated with an opaque, highly reflecting metallic layer. The height of this step is measured by using the highly reflecting layer as one surface of an interferometer and viewing the multiple-beam fringe system by reflexion. Provided that the overlayer assumes the exact contour of the surface, this step-height will give the thickness of the film underneath.

There are two ways in which a sharp edge can be given to an evaporated film. Part of the substrate can be shielded during the deposition of the film, the shield being removed for the deposition of the overlayer. Alternatively, Scott, McLauchlan and

Sennett[3] have suggested that a sharp-edged step could be formed by gently drawing a not-too-sharp needle across the film prior to the deposition of the overlayer so that the film is removed, leaving a clear channel. However, they point out that care must be taken not to mar the substrate, in their case glass, marring being detected by the shape of the fringes.

In the course of investigating the adhesion of thin films to glass[3], it was found that serious errors could be made in the measurement of the thickness of the films when the method described by Scott, McLauchlan and Sennett was used. A number of metals were investigated, and in each case a film of the metal was deposited by evaporation on to a glass surface, a sharp edge being given to each film by covering part of the substrate during deposition. A number of channels was also made in each film by drawing a loaded steel point of smooth contour across the film surface. The point used in this investigation had a tip radius of 0·003 cm. and the load on the point was varied from 0 to 500 gm., the glass substrate tending to crack at this upper limit. The film and the substrate were then coated with an opaque silver layer and the film thickness and the depths of the channels or scratches were measured by viewing the multiple-beam interference fringes of equal thickness by reflexion. The results of one such set of measurements are shown in Fig. 1. In this case, the thickness of a chromium film was found to be 302 A., but the depth of the scratches made at loads greater than about 5 gm. were always greater than this value and increased with the load on the point. It has been shown[4] that plastic deformation of the glass substrate occurs when a load exceeding 2 gm. is applied to a point of tip radius 0·003 cm. pressing on it. It was found that the load required on the point to give a clear channel depended upon the adhesion of the metal film to the glass substrate and, for nearly all the films examined, a load greater than 2 gm. was required to give a clear channel. Therefore, deformation of the substrate would occur. Variation of the tip radius of the point would not eliminate the deformation of the substrate since it has been shown[4] that when the radius is decreased plastic deformation occurs at even lighter loads, whereas, when the radius is increased, a greater load is required to give a clear channel.

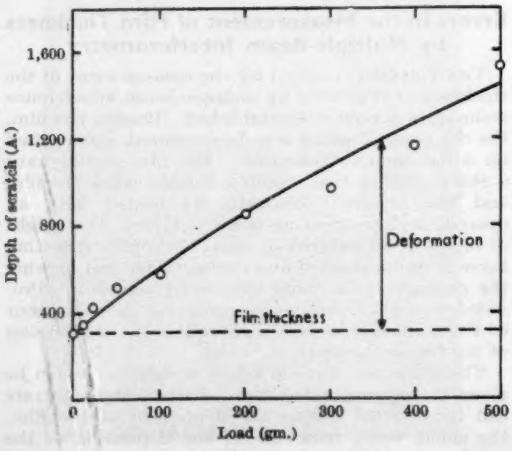

Fig. 1

Table 1

Metal	Load for clear channel (gm.)	Deformation of substrate (A.)
Silver	7	23
Gold	2	0
Copper	30	160
Aluminium	5	18
Antimony	—	—
Chromium	100	273

Scott, McLauchlan and Sennett measured the thickness of films of silver, gold, copper, aluminium, antimony and chromium. Table 1 shows the load on a point of radius 0·003 cm. required to give a clear channel in films of these metals together with the deformation of the substrate. It can be seen that if the depth of the channel was taken as the film thickness then very serious errors could occur, especially if the film adheres strongly to the substrate and a large load is required to give a clear channel. Scott, McLauchlan and Sennett have stated that a check was made between the film thickness and the depth of the channels and good agreement was found. However, it is possible that this check was made on a poorly adherent film such as silver, where the discrepancy would be within the experimental error, and this would account for the agreement.

It can be seen that even when a light pressure is applied to a point to give a channel by which the thickness of a film may be measured serious errors occur. These errors are even greater when excessive pressure has to be applied to the point to obtain a clear channel in a film which adheres strongly to the substrate. It appears that this method of forming a sharp edge to the film is unsatisfactory, and any measurements made using this technique should be treated with caution.

One of us (P. B.) wishes to thank the Metropolitan-Vickers Electrical Co., Ltd., for the provision of a postgraduate scholarship to undertake this work.

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Sept. 19.

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Calculation of Absorption Peaks in Thin Metal Films

The refractive index of an absorbing medium can be written as $N = n - ik$, where n and k refer to the real and imaginary components of the complex quantity N. In this notation the value of n retains the velocity relationship of a simple non-absorbing medium, and k is the extinction coefficient. Another form of the equation has, however, found common usage, particularly with early workers in the field of metal optics; in this form the refractive index N' is defined by $N' = n'(1 - ik')$. It can be seen that N is related to N' by the equations $n = n'$ and $k = n'k'$.

Confusion between these two forms has led to some errors in the evaluation of data recorded in standard

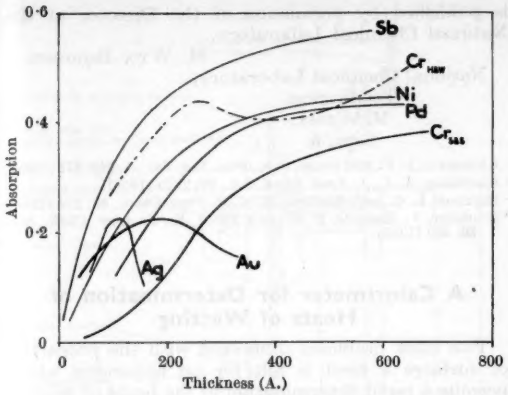

Fig. 1

reference books, for the quantities are commonly listed as n and k with no obvious correlating expression. Sennett and Scott[1] have been led into this type of error in an estimation as to the presence of peaks in the absorption/thickness curves for very thin metal films. Using Maxwell Garnett's equations[2], which are based on a theory of spherical aggregation within the metal films, they deduced that for a peak to be present in the absorption curve a quantity K, given by :

$$K = 2(k^2 - n^2)^3 - 9(k^2 - n^2)^2 + (12 + 8n^2k^2)(k^2 - n^2) - 4 - 12n^2k^2 \quad (1)$$

would have to be positive. Listed in Table 1 are the values that they obtained for K using values for the refractive indices of the metals listed in the International Critical Tables[3]. The variation of absorption of these metals with thickness is given in the full line curves in Fig. 1. From equation (1) it can be seen that the notation used by Sennett and Scott is that defined here by N, but the values of the refractive index components taken from the Tables correspond to $N' = n'(1 - ik')$.

Table 1

Metal	Wave-length	$N = n - ik$		K (ref. 1)	K (recalculated)
		n	k		
Silver	5890 A.	0·18	3·71	$+1·5\times10^8$	$+3·7\times10^8$
Gold	4000 A.	1·58	1·78	$-1·07\times10^2$	$-49·7$
	5800 A.	0·42	2·79	$+1·7\times10^6$	$+5·28\times10^2$
Copper	3950 A.	1·17	1·76	$-5·3$	$+7·44$
	6000 A.	0·56	3·08	$+5·2\times10^4$	$+1·09\times10^3$
Aluminium	5890 A.	1·28	4·69	$+2·0\times10^3$	$+1·87\times10^4$
Antimony	5890 A.	3·04	4·95	$-2·6\times10^5$	$+3·01\times10^4$
Nickel	5890 A.	1·79	3·33	$-35·0$	$+1·05\times10^4$
Palladium	6000 A.	1·92	2·52	$-2·7\times10^3$	$+2·32\times10^3$
Chromium	6080 A.	3·28	4·30	$-4·4\times10^3$	$+4·28\times10^4$

The values of K have been recalculated, using the corrected values for the refractive indices (Table 1, column 6), and little agreement has been found between the sign of K and the presence of absorption peaks. Furthermore, it is not considered likely that properties of this type, depending as they do on the conditions of preparation of the films, could be forecast with any accuracy from bulk metal values of refractive index. The Maxwell-Garnett model assumes the presence of a large number of discrete, spherical particles separated by free space, and as Sennett and Scott have already shown in the case of silver films[1] this holds only for very small values of film thickness. Thicker films show a much more continuous structure, which may or may not possess bulk properties. The transition from one structure to the other has been shown by a variety of experimental methods[4,5], and in all cases the properties being measured change widely with film thickness. Where, however, a film could be induced to grow as a series of perfect monolayers, each possessing the same optical properties, then the refractive index would remain constant, and for large thicknesses bulk material would be obtained. For this type of model structure measurements made on the bulk material would give valid results for thinner films.

In the course of an investigation into the structure of evaporated chromium films it has been shown that the optical constants vary widely with the thickness of the films[6], and that the effective refractive index of the complete film is not at all like that of the surface. Indeed, close agreement has been found between the effective refractive index of the surface layer of a thick film of chromium and of the bulk metal[7]. In this investigation the absorption curve was obtained and this is shown dotted in Fig. 1. The refractive index of the surface layer using the notation $N = n - ik$ was measured as $1·18 - 0·944i$, and the effective refractive index of the whole film was measured as $0·64–1·25i$; the former gave a value of K of $-30·2$, and the latter $-0·72$. As the growth has been shown not to follow the Maxwell Garnett pattern, little agreement could be expected and a peak was obtained in the absorption curve. The particles of these chromium films have, however, been found to follow more closely the David–Schopper[8,9] model of ellipsoids of revolution, but in this case differentiation of the equation for the absorption in order to determine the new form for equation (1) appears impossibly complex.

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Stability of Evaporated Films

It has often been assumed that metal films condensed at a low temperature ($-183°$ or $-195°$ C.) are stable after warming several times to around room temperature. The recent work of Klemperer and Stone[1] and Rosenberg[2] on evaporated nickel and cleaved germanium surfaces respectively suggests that physical changes occur at the surface during oxygen chemisorption. Harrison and Morrison[3] have postulated that similar changes occur when sodium chloride surfaces, formed by evaporation, are kept *in vacuo* at room temperature. These physical changes result in a decrease in area of the respective surfaces, Klemperer, Stone and Rosenberg detecting the process by the physical adsorption of krypton, Harrison

and Morrison deducing it from results obtained by an isotopic exchange technique.

In this Laboratory a fundamental study of the interaction of oxygen with iron surfaces is being carried out, and it is therefore important to determine whether this change in surface area can occur with evaporated iron films after the usual warming and cooling process has been repeated several times.

Chemically 'clean' surfaces were prepared by evaporation in a high-vacuum greaseless apparatus. An iron film condensed at −195° C., of weight 6 mgm. and apparent area 130 cm.², was warmed several times to room temperature (with intermittent cooling to −195° C.) before starting adsorption experiments.

Krypton isotherms determined at −195° C. on a clean surface and on the same one having chemisorbed 220×10^{-3} cm.³ (S.T.P.) oxygen at an immeasurably fast rate at an equilibrium pressure of 10^{-5} mm. and 24° C. are shown in Fig. 1. (This quantity of oxygen is the maximum that the iron surface would adsorb in this manner; further oxygen uptake occurred at a measurable rate.) Using the theory in ref. 4, these isotherms correspond to krypton monolayers of 57×10^{-3} cm.³ (S.T.P.) and 33×10^{-3} cm.³ (S.T.P.) for the clean and oxidized surfaces respectively. The fast chemisorption of oxygen has thus resulted in a decrease of the surface area to 0·23 of its original value.

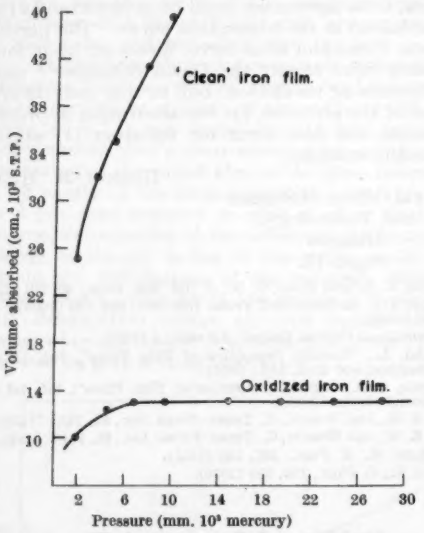

Fig. 1. Krypton isotherms at −195° C.

The effect of 'ageing' a clean iron film *in vacuo* at 24° C. was then considered. An iron surface, prepared as described above, was kept at a pressure less than 10^{-6} mm. at 24° C. and the surface area measured after various time-intervals. It was shown that the surface decreased in area with time. This effect is, however, of a smaller magnitude than that observed during oxygen chemisorption, the area decreasing to 0·72 of its original value in 20 hr.

It is evident that such changes in surface area must be taken into account in interpreting results with evaporated surfaces. A fuller account of this work will be given elsewhere. This communication is published by permission of the Director of the National Chemical Laboratory.

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A Calorimeter for Determination of Heats of Wetting

For most problems connected with the properties of surfaces a need is felt for an apparatus which permits a rapid determination of the heats of adsorption. A suitable calorimeter was constructed, therefore, to determine the heat evolved when solid surfaces come into contact with different amounts of liquids. The calorimeter can determine heats of adsorption as low as 0·001 cal./gm. and the time of each determination is of the order of 30 min.

The apparatus consists essentially of a cell filled with an adsorbent, thermocouples placed in direct contact with the adsorbent, and a suitable jacketing arrangement. The cell is kept at a constant temperature and a liquid is allowed to flow through the cell at a constant rate. When the liquid comes into contact with the solid, a temperature rise is produced and measured by the thermocouples. The heat of adsorption of the liquid on the solid is evaluated by reproducing the temperature rise by passing a known current through a heater situated in the centre of the cell. Heats of replacement of one liquid by another liquid on a given adsorbent may be estimated by allowing a carrier liquid to flow through the cell at a constant rate and introducing into this liquid the second material.

In Fig. 1 a calorimeter with 13 thermocouples is shown. An ice bath encloses the cell containing adsorbent. A capillary jet is attached to the end of the separating funnel containing the carrier liquid and the bore of the jet controls its rate of flow. A small plug of cotton-wool retains the adsorbent in the cell. The hot junctions of the thermocouples are situated immediately above the plug and are sealed, by means of a casein glue, into the wall of the cell. The ends of the thermocouples are only slightly protruding from the wall and are in direct contact with the powdered solid. A coil of nichrome wire possessing a resistance of 10 ohms is situated in the centre of the cell. The coil is used to reproduce the effects taking place during adsorptions, by passing through it a small current from a source of constant known voltage, for a given length of time.

A glass tube is connected directly to the cell and extends to a special attachment which is used for introducing small quantities of unknown substances from a micrometer syringe, while a carrier liquid flows continuously through the apparatus. Enamelled copper and constantan wires (32 S.W.G.) are used for the thermocouples. The thermojunctions are made by twisting the bare ends of the wires together and brazing with the minimum amount of silver. The wires from the hot junctions pass out of the glass jacket, through holes in the rubber bung to the outside of the jacket, where the cold junctions come into direct contact with the ice. The cold

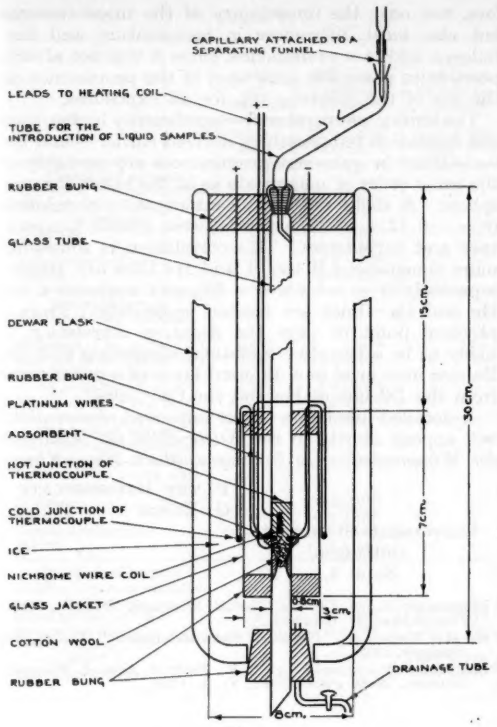

Fig. 1

junctions are held in position by a series of rubber bands. The ends of the two connecting copper leads are joined to either a galvanometer or a potentiometric recorder.

An illustration of the results that can be obtained with the calorimeter is given by the temperature rises produced by wetting of silica gel by a number of organic liquids. In Fig. 2 the temperature of the cell is plotted against the time, and the peaks shown represent the increases of temperature produced by the successive wetting of the adsorbent by *n*-decane, 1-dodecene, *m*-xylene, α-methylnaphthalene, *m*-cresol, *iso*propyl alcohol and acetone. In each case 0·05 ml. of a substance was injected into the carrier liquid consisting of *n*-heptane. (For acetone only 0·025 ml. was injected.) It is noteworthy that *n*-decane gives a measurable response when the carrier liquid is another paraffin, *n*-heptane. Substances of different chemical type give a much greater response.

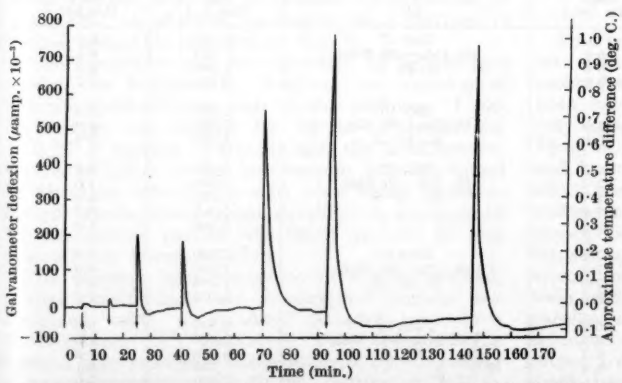

Fig. 2. Temperature rises produced by various substances. Peaks (indicated by arrows) from left to right: decane, 1-dodecene, *m*-xylene, α-methylnaphthalene, *m*-cresol, *iso*propyl alcohol, acetone

This work was initiated in the laboratories of Benzole Producers, Ltd., and is the subject of Patent Application No. 38305/57 in their name.

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Capillary-tube Viscometry with Negligible Kinetic Energy Effects

The uncertainties associated with the kinetic energy correction in conventional capillary-tube viscometry result in considerable inaccuracy and inconvenience. These uncertainties arise from the dependence of the kinetic energy 'constant', B, on flow-rate and on the form of the capillary ends, B being defined by the equation:

$$\nu = Ct - B/t$$

where ν is the kinematic viscosity, t is the time of flow and C is the principal calibration constant. The significance of the kinetic energy term in the accurate measurement of the viscosity of liquids using capillary viscometers was emphasized at the recent symposium[1] arranged by the Institute of Petroleum and the British Society of Rheology.

In the course of work carried out during the past two years at the National Standards Laboratory, Sydney, capillary viscometers of both U-tube and Ubbelohde types have been developed in which the kinetic energy effect is entirely negligible. Since the viscometers are but little more difficult to construct than those employed in the usual standard procedures, as exemplified in B.S.S. 188 : 1957, they could with profit be adopted for those procedures.

The practical elimination of the kinetic effect is achieved by forming a gradual flare, generally a few centimetres long, at each end of the capillary tube. The flares may be so long as to run together at the centre of the tube, which then possesses no parallel part. Using viscometers with the capillary ends flared in this way, it has been found that the value of B is reduced to less than 0·02 of its value for otherwise similar conventional viscometers used at the normal flow-rates. In a series of measurements at higher flow-rates it was found that the kinetic energy effect could only be detected with certainty at flow-rates corresponding to Reynolds numbers exceeding three times the highest values encountered in conventional viscometry. At much higher flow-rates the value of B for the flared capillaries used in these experiments increased monotonically with Reynolds number, reaching, for example, about half the usual value at a Reynolds number of a thousand.

The long flare is readily produced by applying pneumatic pressure to a parallel capillary tube, with the end sealed, while it hangs in a temperature

gradient in a furnace. A uniform temperature gradient is suitable.

A detailed account of this work has been submitted for publication elsewhere.

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Temperature and Turbulence in Quiescent Prominences determined from Line-widths

Some years ago, one of us attempted to determine the kinetic temperature of atoms and a possible turbulence in some quiescent prominences[1]. Since at that time the different lines of a prominence had to be exposed one after the other and since only Hβ and D3 could be used for the purpose, it seemed desirable to make further observations of solar prominences with improved equipment[2].

The present observations were made with our tower telescope ($f = 24$ m.) using a Bausch and Lomb concave grating (radius of curvature 665 cm.). The prominences were guided on to the slit of the spectrograph (height of the slit 0·6 mm.) by using a Lyot Hα filter[3]. The following lines—arising with good approximation in an optically thin layer—could be exposed simultaneously : λ 8542 and (in some spectra) λ 8498 of Ca+, λ 5875 of He, λ 4340 and λ 3970 of H, the Balmer lines in the second order, the other lines in the first order. Since the molecular weight of calcium is forty times greater than that of hydrogen, the separation of temperature and turbulence is fairly certain. All line-widths have been corrected for the finite resolving power of the spectrograph.

Table 1 gives the results for ten quiescent prominences. The temperatures and the turbulent velocities are mean values computed according to the method of least squares, giving double weight to the widths of the Balmer lines. The different values given for one and the same prominence belong to different exposures. The scatter expresses, therefore, not only the uncertainty of the measurements but also local differences in temperature and turbulence within a prominence, since it was not always possible to place the same spot of the prominence on the slit of the spectrograph for all exposures.

The kinetic temperatures—significantly higher than the excitation temperatures derived earlier[1]—and the turbulence in quiescent prominences are probably of the same order of magnitude as in the lower chromosphere. A slight but significant negative correlation ($r = -0{\cdot}52$, $n = 39$) exists between kinetic temperature and turbulence. This correlation is somewhat more conspicuous if the H and He lines are treated separately ($r = -0{\cdot}64$, $n = 35$), and is absent if the He and Ca+ lines are treated separately. From a physical point of view the negative correlation is likely to be a pseudo-correlation, suggesting that the Balmer lines arise in a different layer of a prominence from the D3 line of He and the Ca+ lines.

A detailed discussion of our improved observations will appear shortly in the *Nachrichten der Akademie der Wissenschaften in Göttingen, Math.-Phys.-Klasse.*

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Electron Spin Resonance in Carbons : a New Oxygen Effect

Ingram and Tapley[1] and Uebersfeld and Erb[2] have observed that electron spin resonance in certain carbons can be affected by oxygen. Austen and Ingram[3] showed that the electron spin resonance signal given by a carbon in vacuum may be (*a*) broadened, (*b*) reduced in total integrated intensity, by exposure to oxygen at room temperature. In both cases, it was found possible to restore the signal to the value it possessed in vacuum by outgassing the sample for a few minutes at room temperature.

Table 1

U.T. 1957	T_{kin} (deg.K.)	v_{turb} (km./sec.)	U.T. 1957	T_{kin} (deg.K.)	v_{turb} (km./sec.)
May 1			May 11	7,000	6·3
6h. 24m.–6h. 35m.	4,800	9·2	9h. 45m.–10h. 00m.	7,100	6·1
W., 40° S.*	5,000	9·0	E., 35° N.	5,200	6·1
	4,800	9·2		5,100	5·7
May 1			May 15	6,300	3·9
7h. 00m.–7h. 14m.	6,500	4·9	6h. 35m.–6h. 45m.	7,000	3·9
E., 30° S.	5,900	5·0	E., 10° N.	8,200	3·6
May 9	9,300	4·9	May 25	6,300	3·6
13h. 45m.–14h. 00m.	8,600	5·7	8h. 25m.–8h. 45m.	7,000	4·8
W., 63° S.	5,500	6·7	W., 10° S.	6,800	3·8
	5,900	7·1		6,000	3·9
	6,000	6·3		5,500	4·8
May 9	5,800	7·6	June 13	7,600	5·6
14h. 30m.–14h. 45m.	5,200	7·5	6h. 12m.–6h. 21m.	7,900	4·9
E., 33° N.	4,600	7·6	E., 40° N.	7,300	4·9
	4,500	8·6		6,500	5·0
May 10	7,500	6·5	June 13	8,800	6·6
8h. 10m.–8h. 15m.	6,900	6·7	16h. 04m.–16h. 30m.	5,900	7·3
E., 33° N.	6,300	6·1	W., 0°	5,000	7·3
	4,500	6·4		7,700	6·1
				6,600	7·0

* Position of prominences according to "Daily Maps of the Sun", Fraunhofer Institut, Freiburg im Breisgau.

Table 1

	Acidity of carbon (micro-equiv./gm.)	Total free radical concentration (free spins/gm.)	Gas produced by decomposition (micro-mole CO_2 / gm. CO)	
Unoxidized carbons (prepared by carbonization at 700° C. for 1 hr. in vacuum)				
Cellulose	350	$10{\cdot}4\times10^{19}$	—	—
Sucrose	190	$23{\cdot}4\times10^{19}$	—	—
Polydivinylbenzene	170	$18{\cdot}5\times10^{19}$	—	—
Starch	110	$18{\cdot}4\times10^{19}$	—	—
Oxidized carbons (Unoxidized carbons heated in air)				
Cellulose (½ hr. at 300° C.)	1,450	$<10^{18}$	—	—
Sucrose (3 hr. at 350° C.)	2,640	$7{\cdot}5\times10^{19}$	—	—
Polydivinylbenzene (½ hr. at 350° C.)	3,680	$6{\cdot}3\times10^{19}$	—	—
Starch (2 hr. at 350° C.)	3,630	$8{\cdot}6\times10^{19}$	—	—
Neutralized carbons (oxidized carbons neutralized with 0·26 *N* sodium hydroxide at room temperature)				
Cellulose	—	$6{\cdot}9\times10^{19}$	—	—
Sucrose	—	$10{\cdot}2\times10^{19}$	—	—
Polydivinylbenzene	—	$9{\cdot}5\times10^{19}$	—	—
Starch	—	$12{\cdot}8\times10^{19}$	—	—
Decomposed carbons (oxidized carbons reheated in vacuum)				
Cellulose (to 550° C.)	860	$5{\cdot}3\times10^{19}$	835	910
Sucrose (to 550° C.)	1,230	$12{\cdot}8\times10^{19}$	1,020	930
Polydivinylbenzene (to 580° C.)	970	$13{\cdot}5\times10^{19}$	1,680	1,740
Starch (to 570° C.)	2,270	$12{\cdot}8\times10^{19}$	1,370	760

We have observed an oxygen effect with carbons which we believe to be quite distinct from that described by previous workers. In this case, oxidation of the carbon at more elevated temperatures produced a reduction in the total concentration of free radicals, which could not be restored by outgassing the sample at room temperature.

Carbons were prepared by heating cellulose, sucrose, starch, and pre-oxidized polydivinylbenzene in vacuum to 700° C. After cooling in vacuum, these carbons were oxidized by heating in air at a temperature in the region of 300–400° C.; details of the oxidation treatment are given in Table 1. After a preliminary outgassing for 24 hr. at room temperature, the oxidized carbons were reheated in vacuum. This treatment decomposed some of the surface oxide with the production of a volume of gas which, on analysis, proved to be a mixture of carbon monoxide and carbon dioxide.

The formation and decomposition of acid surface oxide[4] was followed by studying the sorption of sodium hydroxide by each of the carbons. 1 gm. of carbon was shaken for 24 hr. with 30 ml. of 0·26 *N* sodium hydroxide and the final concentration of alkali in the supernatant solution found by titration with dilute acid, care being taken to exclude atmospheric carbon dioxide. A specimen of the neutralized carbon was dried at 100° C. and examined as described below.

The electron spin resonance of the unoxidized, oxidized, neutralized and 'decomposed' carbons was examined using a standard X-band microwave spectrometer. All specimens were prepared for electron spin resonance measurements by outgassing at room temperature for 20 hr., heating at 200° C. for 1 hr. and finally sealing in vacuum. It seems certain, therefore, that the oxygen effect described by previous workers[1–3] was not occurring in these experiments.

In general, the unoxidized specimens possessed large electron spin resonance signals (Table 1). When oxidized, the samples showed a large increase in acidity, while the total concentration of free radicals was considerably reduced. By heating the oxidized sample in vacuum at about 550° C., some of the surface oxide was decomposed and the signal was partially restored. Neutralization of the oxidized material with sodium hydroxide also caused a partial recovery of the electron spin resonance signal.

We attribute the reduction in concentration of total free radicals on oxidation to the formation of surface oxide, as indicated by the increased acidity of the specimens. The partial recovery of the electron spin resonance signal on reheating the oxidized carbon provides further confirmation of the idea. The adsorbed oxygen appears to be more tightly bound than that encountered by Austen and Ingram, since it was not removed during the outgassing treatment but only at higher temperatures, as a mixture of carbon monoxide and carbon dioxide. It seems possible that, in the earlier work, the oxygen molecules were weakly adsorbed as a charge-transfer compound of the type described by Mulliken[5], whereas our results appear to be due to the formation of covalent oxides. The possibility is therefore raised that the electron spin resonance of carbons prepared from materials containing oxygen may be dependent, to some extent, on the proportion of oxygen retained by the structure during carbonization. The behaviour of sodium hydroxide in partially restoring the concentration of radicals of oxidized carbons is not yet fully understood, but further work is being carried out to clarify this effect.

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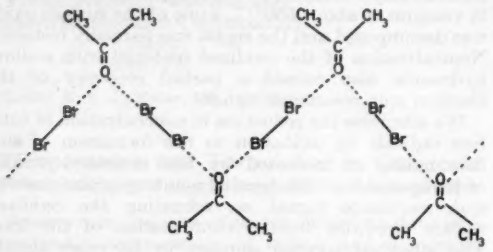
Halogen-Molecule Bridges in Solid Addition Compounds

One very striking result obtained from X-ray work on solid addition compounds in which halogen molecules act as electron acceptors is the fact that both halogen atoms of a particular Hal_2 molecule may simultaneously be linked to donor molecules. Thus, in the 1 : 1 compounds formed by 1,4-dioxan and bromine (or iodine) endless chains are present which are built up of alternating dioxan and halogen molecules and containing linear O—*Hal*—*Hal*—O arrangements[1]. Moreover, in the solid 1 : 1 compound formed by benzene and bromine, straight chains of alternating benzene and bromine molecules have been established[2]; the benzene-ring planes are parallel and the bromine molecules symmetrically arranged on the common chief axis of the benzene rings. Until quite recently it was uncertain whether more than one single halogen-molecule bridge could actually start from one particular electron donor atom. In the case of oxygen and other donor atoms

possessing more than one lone electron pair such an arrangement would not appear to be impossible.

The 1 : 1 compound between acetone and bromine actually affords an example of this kind. According to new results the crystals of this compound contain endless chains of the type :



Here, both lone electron pairs belonging to a particular keto oxygen atom evidently take part in halogen bond formation. The keto carbons and oxygens and the bromine atoms belonging to the same chain are coplanar and the O—Br—Br—O arrangements strictly linear. The methyl carbons do not appear to lie exactly in the plane of the other atoms of the chain. This is probably so because otherwise the distances between methyl carbons and bromine atoms would be energetically unfavourable. The Br—Br distance appears to be very little different from the distance observed in the free molecule (2·28 A.). The O—Br distance was found to be 2·82 A. and the Br—O—Br angle nearly 110°. Details of the structure determination will be published elsewhere. The space group is $C2/c$ and the lattice parameters are as follows :

$a = 7{\cdot}12$ A. $b = 7{\cdot}48$ A. $c = 12{\cdot}90$ A. $\beta = 111{\cdot}5°$

The unit cell contains four molecules.

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Boron-10 Abundance in Nature

The most reliable values for the isotopic abundance of boron-10 in naturally occurring minerals have been derived from mass spectrometer measurements. Results quoted by different workers, however, range from 18·4 to 19·9 per cent boron-10, and it is not difficult to find possible causes for the variation. Most of the measurements have been made with boron trifluoride, which is a difficult compound to handle in a mass spectrometer, since memory effects and interference from impurities can give very erratic and incorrect results ; even when there are no errors of this kind, it is still possible for results to be biased by mass discriminations in the mass spectrometer, and no reported attempts have been made to standardize the results in any way. Insufficient care when preparing samples from the natural minerals could also cause errors arising from discrimination with respect to one isotope. The possibility of variation of the abundance of boron-10 in Nature has been investigated by Parwel *et al.*[1], who examined a large number of minerals and found only a slight difference for boron obtained from sea water.

Among the more recently reported results, Osbergaus[2] quotes a constant value of 19·6 per cent boron-10 for a small number of minerals examined. Panchenkov and Moissev[3] quote 18·4 per cent boron-10 for (presumably industrially prepared) boron trifluoride. Kilpatrick *et al.*[4] claim to have eliminated their mass discriminations and quote 18·8 per cent boron-10 for industrially prepared boron trifluoride.

In order to make a check on mass spectrometer discriminations and to obtain a more accurate figure for the natural abundance of boron-10, we have prepared standard samples of boron trifluoride with known isotopic content. Primary standards were prepared by blending enriched and depleted boron trifluoride in known proportions, and these were compared with bulk secondary standards using a mass spectrometer. We later compared the appropriate secondary standard with a sample of boron trifluoride which had been carefully prepared from naturally occurring boron. This sample has been shown by Parwel *et al.*[1] to contain boron with the same isotopic composition as that obtained from all the other minerals they examined ; we are indebted to H. von Ubisch of A. B. Atomenergi, Stockholm, for supplying this sample. Our results show that the mass spectrometer discriminations, expressed as a fraction of the isotope ratio, are the same for both enriched and natural boron trifluoride, as might be expected. The naturally occurring boron sample was found to contain $(19{\cdot}3 \pm 0{\cdot}1)$ per cent of boron-10.

A more detailed account of the preparation of the isotopic standards and of the mass spectrometer measurements will be published elsewhere.

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Surface Concentrations of Manganese Nodules

Manganese nodules were investigated during the Downwind Expedition, a part of the International Geophysical Year programme of the Scripps Institution of Oceanography of the University of California. Attempts were made to collect bottom photographs, cores and dredge hauls in the same areas, to measure the distribution at the surface and in depth, and to obtain large samples for physical and chemical analysis.

Although nodules were sampled and photographed in various places along the expedition track between California, Tahiti and South America, the greatest concentration was found on the red clay bottom deeper than about 4 km. in the south-western Pacific Basin. Nodules had been discovered in the basin by the *Challenger* eighty-five years before. The two ships of the expedition followed the track of

Table 1. DOWNWIND EXPEDITION BOTTOM PHOTO STATIONS SHOWING ABUNDANT MANGANESE NODULES

Station No.	Region	Latitude	Longitude	Depth in metres	Per cent of bottom covered	gm.cm.$^{-2}$
DWP–2	Baja Calif. Smt. Prov.	10° 25′ N.	130° 35′ W.	4,712	Abundant	
DWP–5	French Polynesia	18° 31′ S.	141° 23·5′ W.	4,080	Abundant	
DWP–8	French Polynesia	21° 37′ S.	147° 40′ W.	4,684	26	2½
DWP–10	South-western Pacific Basin	32° 08′ S.	140° 30′ W.	4,754	23	1
DWP–11	South-western Pacific Basin	42° 50′ S.	125° 32′ W.	4,560	46	4

the *Challenger* and explored a narrow band about 2,700 km. long in a south-easterly direction from latitude 25° S. to 45° S. in the eastern part of the basin. Two bottom photographs, twenty-three gravity cores and two dredge hauls were obtained. Photographs (Fig. 1) indicate that about a quarter to a half of the sea floor in this basin is covered with manganese nodules and that the weight per unit area is about 1–4 gm. cm.$^{-2}$ (Table 1). The surface concentration was determined by standard statistical procedures. Density of the nodules is about 2·0 gm. cm.$^{-3}$. The scale of the photographs is known, and the volume of the nodules can be estimated because the smaller nodules are roughly spherical and the lengths of their shadows give a scale for measuring the thickness of slab-shaped nodules. The sizes computed agree reasonably closely with the sizes dredged.

The group of cores gives less definite evidence of the fraction of the bottom covered with nodules in the south-western Pacific Basin but it provides a means of interpolation between the widely separated camera stations. Some twenty-three gravity cores contained samples as follows: six sediment but no nodules; four manganese oxide fragments in core nose; four small nodules only; nine sediment and nodules including eight with nodules at surface. Omitting one smaller core for uniformity, each of twenty-two cores has a cross-sectional area of 18 cm.^{2}. The four cores with manganese oxide fragments may be assumed to be hits on large nodules each with an area of 18 cm.^{2}. The thirteen cores with nodules alone or nodules and sediment have fifteen nodules at the surface with an average diameter of approximately 1 cm. These figures indicate one-fifth of the bottom is covered with nodules along the transverse. Consequently, the average coverage of nodules indicated by coring is about the same as the minimum shown on photographs. The average coverage from coring would be greater if four other coring attempts were counted as hits on large nodules. On each of these a ball-break indicated that the cores hit bottom, but no sample of any kind was obtained in the cores. However, nodules were indicated by black streaks and scratches not only on corers but on the camera and temperature probe. Similar streaks on equipment were observed in this area during the *Challenger* Expedition[1] and interpreted as indicating very abundant nodules.

Fig. 1. Photo *DWP*–11. Area about 6 m.^{2}

Nodules are not limited to the surface of the sea bottom. Of fifteen cores that penetrated deeper than 11 cm., three contained nodules at depths of 8–11 cm. Of thirteen cores penetrating to 72 cm., six had nodules 48–72 cm. below the surface. No other nodules have been found in a maximum penetration of 140 cm. One core penetrated to approximately 47–50 cm. where a small nodule was lodged in the core catcher. This is the only core which ceased penetrating when it reached one of the nodule-rich zones. Consequently, there is no positive indication that large nodules (which would stop the corer) occur anywhere except at the surface. Moreover, some of the cores may have hit the bottom more than once, with the result that some nodules that appear to be buried in sediment were actually at the surface.

Manganese nodules are a potential resource so that an estimate of the amount in the south-western Pacific Basin may be of interest. The U.S.S. *Enterprise* took a latitudinal line of samples by sounding lead across the basin at about 50° S. Several records of 'black specks' and one 'black stone' may indicate manganese nodules or fragments. No other samples are available, and it is only an assumption that the concentration of nodules found along the Downwind track is characteristic of the whole basin. The basin deeper than 4 km. has an area of roughly 10^7 km.^{2}. If the concentration of nodules is uniform at 1 gm. cm.$^{-2}$, the total weight of the surface deposit is 10^{17} gm. Average chemical analyses of Pacific nodules suggest that iron and manganese are present in the deposit in amounts of 10^{16} gm., and cobalt, copper and nickel and rare earths each amount to 10^{15} gm.

Dredge hauls and cores show that nodules are distributed within perhaps 5×10^7 km.^{2} of the Pacific Basin, but little is known about the concentration per unit area. Photograph *DWP*-8 in French Polynesia indicates that nodules cover about a quarter of the surface, but the photograph is oblique and subject to greater errors of interpretation than photographs *DWP*-10 and -11 (Fig. 1). Similar concentrations are suggested by photographs in other areas, but the nodules are partially covered with sediment and only rough estimates are justified. Nevertheless, the scanty evidence available suggests that manganese nodules cover a considerable fraction of the deep sea floor in many parts of the Pacific Basin. This circumstance presents a puzzle, because the upward growth of nodules may be one or two

orders of magnitude slower than commonly accepted average deposition rates of sediment in the deep sea[2].

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Diffusion of Zinc in Gallium Arsenide

Zinc is an acceptor impurity in gallium arsenide with small ionization energy. If it is the predominant impurity and is present in low enough concentration, then the Fermi-level will lie above the zinc-levels and the zinc atoms will nearly all be ionized, that is, they will have accepted an electron. As the zinc concentration increases, the Fermi-level will descend into the valence band and the proportion of ionized atoms becomes small. Since the speed of diffusion of an atom will be different in its ionized and in its un-ionized state the diffusion coefficient will depend upon concentration.

The conditions under which one might observe this effect are as follows. We define a critical concentration N_0 of zinc atoms above which most of them will not be ionized, and below which most of them will be. Then we require the surface concentration to be greater than N_0 and the intrinsic number of holes and electrons to be small. These conditions can easily be satisfied for zinc diffusing into gallium arsenide at 1,000° C. We have worked out the theory of this system and in Fig. 1 we show a theoretical curve of impurity concentration as a function of distance into a specimen when the diffusion is into a semi-infinite block with constant surface concentration of impurity. Also shown are some experimental points obtained by a radioactive tracer method. The agreement between theory and experiment is seen to be quite good. The most interesting feature of the curve is the change in slope when the concentration is equal to N_0, giving a very steep diffusion front, and this effect will obviously be of importance in design problems.

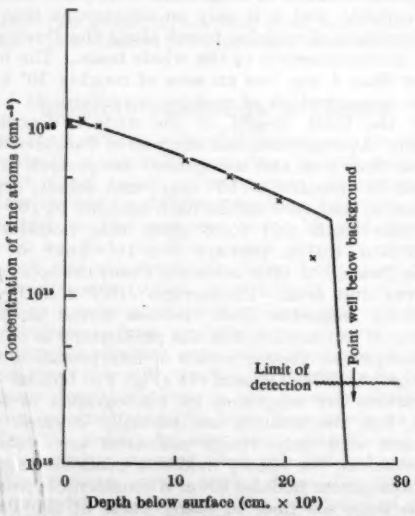

Fig. 1. Diffusion of zinc-65 in gallium arsenide. Temperature of diffusion 1,000° C.; time of diffusion, 3·25 hr. ——, Theoretical curve. ×, Experimental points

Two further points emerge which may be stressed. First, we can find from our analysis of the experimental results the diffusion coefficient of zinc in both the ionized and the un-ionized states. Preliminary measurements show that at 1,000° C. the diffusion coefficient of un-ionized zinc is about thirty times greater than that of ionized zinc. This is reasonable, since when the zinc has accepted an electron it is presumably more tightly bound and is also larger. We hope to find the two coefficients as a function of temperature in order to compare the activation energies. Secondly, the effects are particularly pronounced in the zinc–gallium arsenide system because the conditions enunciated above are well satisfied, but they may occur in other systems to a lesser degree and produce apparent anomalies. For example, it is quite possible to have an apparently normal concentration – depth curve which when extrapolated to the surface yields a value for the surface concentration considerably different from the true value. Full details of the theory and experiments and a discussion of these possibilities will be published elsewhere.

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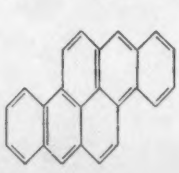
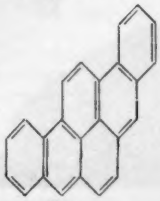
Presence of 3 : 4-8 : 9-Dibenzpyrene in Coal-Tar

Although several carcinogenic hydrocarbons of varied potency have been isolated from coal-tar, including 1 : 2-5 : 6-dibenzanthracene, 3 : 4-benzpyrene[1], and 1 : 12-benzperylene[3], it is known that the presence of such substances is not sufficient to account for both the qualitative and the quantitative carcinogenicity of coal-tar itself. This consideration warranted the search for further carcinogens in coal-tar, particularly in pitch fractions containing the more condensed aromatic hydrocarbons, and especially in view of the considerable carcinogenic activity of several hexacyclic hydrocarbons such as 3 : 4-8 : 9-(I)[3] and 3 : 4-9 : 10-dibenzpyrene (II)[4]. Schoental[5] has recently reported the presence of (II) in a carcinogenic fraction of coal-tar, and this prompted the present report of the isolation of another potent carcinogen, 3 : 4-8 : 9-dibenzpyrene, from similar material. This hydrocarbon, which was isolated in small amounts by the usual fractionation and chromatographic methods, from the fractions boiling above 500° C. of various samples of coal-tar pitch,



(I)



(II)

was identified by direct comparison of melting point and ultra-violet and fluorescence spectra with those of an authentic sample prepared by zinc dust reduction of 3 : 4-8 : 9-dibenzpyrene-5 : 10-quinone[6].

3 : 4-8 : 9-Dibenzpyrene is a carcinogen of particular interest, not only because it has been detected among the constituents of tar from tobacco smoke[7] but also because it has been shown to possess considerable sarcoma-producing activity in male mice of strain XVII of this Institute, whereas female animals of the same strain are far less susceptible[8].

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A Simple, Rapid Method for Circular Paper Chromatography

I have recently developed in our laboratory the following method for the circular development of a large paper disk which has the advantages of (*a*) rapidity, requiring no more than two and a half hours for a satisfactory separation of sugars and amino-acids, and (*b*) simplicity, as it does not need the various devices of other workers[1,2].

Whatman paper disks 26 cm. in diameter are used. In the centre of the paper a circle 1·5 cm. in diameter is drawn with a pencil. Four to eight cuts, depending upon the number of the samples which will be examined, are made from the periphery up to the centre (Fig. 1). The resulting tips of the triangular areas are bent downward. Each spot is applied on the periphery of the circle, between two adjacent cuts. The solvent is placed in a small vessel which is supported on a glass stand in a glass desiccator 25 cm. in diameter, so that the rim of the vessel is approximately 1 cm. below the rim of the desiccator. Then the tips of the triangular spaces are dipped into the solvent and the desiccator is closed. The front develops as a circle, provided that the desiccator is levelled carefully.

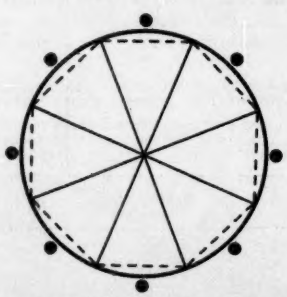

Fig. 1. Diagram showing the cutting and bending of the paper. The solid lines represent the cuts. The broken lines the places where the paper is bent down. The dots represent the spots

Further details of this method will be published elsewhere.

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Configuration of N-acetylneuraminic Acid

Recently, Comb and Roseman[1] observed that N-acetyl-*d*-mannosamine and not N-acetyl-*d*-glucosamine was a substrate for the enzyme synthesizing N-acetylneuraminic acid (nanaldolase) isolated from *Clostridium perfringens*. These results seem to be in conflict with the synthesis of N-acetylneuramic acid from N-acetyl-*d*-glucosamine as reported by Cornforth, Firth and Gottschalk[2]. The observations of Comb and Roseman suggest that N-acetyl-*d*-mannosamine should be the starting product for the synthesis of N-acetylneuraminic acid.

From the reaction mixture of a condensation between N-acetyl-*d*-mannosamine and oxaloacetic acid in aqueous alkaline solution (*p*H 11) at room temperature we isolated an acidic crystalline substance. This acid proved to be identical with N-acetylneuraminic acid isolated from a similar reaction between N-acetyl-*d*-glucosamine and oxaloacetic acid[2]. In both cases the yield was only 1–2 per cent. Variation of the conditions of the reactions and of the relative amount of the reactants did not improve the yield.

Both acids had the same equivalent weight, optical rotation (in water), R_F value (0·13) on Whatman No. 1 paper (descending; butanol/pyridine/water 6 : 4 : 3), intensity of the colour produced with Ehrlich's reagent (measured at 565 mμ), infra-red spectrum in compressed potassium bromide and X-ray powder diffraction pattern (copper K_α). Mr. Boschman of this laboratory found that both substances inhibited influenza virus enzyme to the same degree[3].

The isolation of identical products from the reaction of N-acetyl-*d*-glucosamine and N-acetyl-*d*-mannosamine with oxaloacetic acid appeared to be due to the epimerization of the two amino-sugars under the conditions of the reaction. Aqueous solutions of both amino-sugars (concentration 75 mgm./ml., that is, the same concentration as used in the condensation reaction) were brought to *p*H 11. After standing some time at room temperature the solutions were neutralized with 'Dowex' 50. Samples were run on borate-treated paper with the butanol/pyridine/water (6 : 4 : 3) mixture[4]. Colouring the chromatograms with Ehrlich's reagent after pretreatment with alkali revealed that both solutions contained N-acetyl-*d*-mannosamine as well as N-acetyl-*d*-glucosamine. The epimerization attained equilibrium after 10 hr. as was shown by a determination of the amount of amino-sugar in eluates of the individual spots. At equilibrium the ratio of N-acetyl-*d*-glucosamine to N-acetyl-*d*-mannosamine was 2·2 to 1. After 48 hr., the total amount of amino-sugar was about 75 per cent of the original. Recently, Comb and Roseman[5] have also reported the

epimerization of N-acetyl-*d*-glucosamine in aqueous solution at *p*H 11.

These results indicate that the opinion of Cornforth, Firth and Gottschalk[2] that their synthesis confirms Gottschalk's[6] proposal of the configuration of N-acetylneuraminic acid is not wholly justified. Further, we conclude that the isolation of N-acetyl-*d*-glucosamine after an alkaline degradation of N-acetylneuraminic acid as reported by Kuhn and Brossmer[7] and by Zilliken and Glick[8] can be ascribed to the rapid epimerization of N-acetyl-*d*-mannosamine formed originally. This means that the isolation of N-acetyl-*d*-glucosamine can no longer be taken as a proof of the configuration at C_2 of N-acetylneuraminic acid[7]. Our experiments lend support to the results of Comb and Roseman[1]. This implies that the configuration at carbon atoms 5–8 of N-acetylneuraminic acid is the same as the configuration at carbon atoms 2–5 of N-acetyl-*d*-mannosamine.

We are indebted to Mr. A. H. Bierens and Mr. J. Schut for their assistance.

Note added in proof. R. Kuhn and R. Brossmer (*Ann.*, **616**, 221; 1958) have re-investigated the degradation of N-acetylneuraminic acid with pyridine and nickel acetate[7]. They now find that N-acetyl-*d*-mannosamine is formed primarily and that this rapidly epimerizes to N-acetyl-*d*-glucosamine.

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3-Ethoxy-4-hydroxybenzoic Acid in Human Urine

In a recent communication[1] an increased excretion of vanillic acid during the stress of motor-rally driving was reported. The 1958 Royal Automobile Club rally offered an opportunity to confirm this finding, and three samples of urine were collected from each of two subjects during the third and fourth days. This was after a considerably longer period of stress than had been experienced in the previous experiment and was determined by the accessibility of the subjects. Acid-hydrolysed urines were examined by the method used previously[2] and both hydrolysed and unhydrolysed urines by a modification of the method of Armstrong *et al.*[3]. In all the samples, vanillic acid was detected only in perfectly normal amount.

However, chromatograms of the final sample from one of the subjects showed the presence in comparatively large quantity, particularly after hydrolysis, of an unusual substance which had previously been detected in four of the ten urines in the first experiment, although in comparable amount in only one of them. Further, reference to chromatograms (prepared some years ago by P. S.) of urines from subjects rendered anoxic by decompression for two hours to a pressure equivalent to an altitude of 14,000 ft. showed that a similar substance had been recorded as present in small amount in six of twenty-three such urines. In thirty-eight normal urines collected over a similar period of time (approximately 9.30–11.30 a.m.) from the same subjects (fifteen normals were duplicated) the compound had been detected only twice. Because no particular attention was paid at the time to this then rather obscure substance the numbers quoted above should be regarded with some reservation, since it is possible that trace amounts might have escaped notice on some chromatograms on which its presence had not been recorded.

The new compound was indistinguishable from vanillic acid in its behaviour towards diazotized sulphanilic acid or *p*-nitroaniline, Folin and Ciocalteu's reagent or 2 : 6-dichloroquinone chloroimide[4], but had higher R_F values in all organic solvents tried. These properties suggested a homologue of vanillic acid, and the substance was readily shown to be excreted following ingestion of ethyl vanillin; it has now proved to be chromatographically identical with 3-ethoxy-4-hydroxybenzoic (ethyl vanillic) acid.

Present evidence suggests ethyl vanillic acid may be detected in normal urines, though rarely in more than trace amounts, rather more frequently than is suggested by the anoxia controls mentioned above, particularly in samples collected at different times of the day. One urine collected after lunch contained the substance in large quantity. Inquiry revealed that the subject in question had, during the previous twenty-four hours, consumed a surprising variety of sweets, but no difficulty was encountered in demonstrating the origin of ethyl vanillic acid to be a well-known confection which evidently contains much ethyl vanillin.

From the two driving-stress experiments, urines were collected from two of the subjects, co-drivers, on five occasions, in each case over similar periods of time. On two occasions nothing of interest was found, but the excretions of vanillic and ethyl vanillic acids in the remaining three pairs of urines are compared in Table 1. The average normal excretion-rate for vanillic acid is about 85 μgm./hr. while ethyl vanillic acid is usually present only in trace amounts. Considerable differences between the subjects in the rates of excretion of at least one of the substances are evident on two of the occasions. Since it is known that these two subjects consumed virtually identical meals throughout, and taking into account our present knowledge of dietary sources of the two compounds, we find it difficult to escape the conclusion that both have an endogenous origin responsible for their increase during stress. The alternative possibility that some substance—which

Table 1. Rates of Excretion of Vanillic and Ethyl Vanillic Acids by Two Subjects under Stress

Substances estimated by visual comparisons of chromatograms from acid-hydrolysed urines with known quantities of authentic material. Spots developed with diazotized sulphanilic acid

Subject and occasion	Vanillic acid (μgm./hr.)	Ethyl vanillic acid (μgm./hr.)
J. B. } 1	330	0
A. M. H. B. } 1	420	0
J. B. } 2	30	0
A. M. H. B. } 2	330	20
J. B. } 3	30	150
A. M. H. B. } 3	30	0

must have been eaten by both subjects—can give sometimes vanillic acid, sometimes ethyl vanillic acid, and on other occasions yield no detectable metabolite, seems rather remote.

It is now clear that any conclusion that vanillic and ethyl vanillic acids are metabolites of adrenaline or other catechol of endogenous origin must await the demonstration that biological ethylation of a catechol hydroxyl group is possible, as an alternative to methylation, in the human subject. Work at present on hand indicates strongly that this is so, but results so far have been insufficiently impressive and too erratic to merit publication at this stage.

We wish to thank the Director-General of Medical Services, Royal Air Force, for permission to publish this work, which will be presented in more detail elsewhere, and Dr. A. M. H. Bennett for his continued co-operation in the collection of urines.

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Purkinje and Ventricular Membrane Resistances during the Rising Phase of the Action Potential

Using double-barrelled micro-electrodes, one barrel for recording the other for passing current, it has been found possible to observe the effects of hyper- and de-polarizing currents on the membrane behaviour of actively beating heart muscle.

An isolated preparation of rabbit right ventricle was driven at a constant rate (approximately 3/sec.) via external electrodes. Purkinje fibres were distinguished by their characteristic action potential and appeared to be localized to the endocardial surface in a sparse network of pale tissue bands similar to those described by Purkinje[1]. Rectangular pulses of current of 100 msec. duration were applied via one barrel of the micro-electrode 80 msec. before the onset of every fourth propagated action potential. Because of the proximity of the two barrels and the relatively high currents required (10^{-6}–10^{-6} amp.) it was not possible to compensate entirely for the artefacts which appeared at the recording electrode, and thus direct determination of the changes in membrane resting potential during the passage of a current pulse was not possible. However, the technique did permit the following measurements to be made: the maximum amplitude of the normal action potential, E_n; the maximum amplitude of the action potential occurring during current flow, E_c; and the applied current, I.

Assuming the current produced no change in membrane behaviour, the following would hold:

$$\frac{dE_c}{dI} = R_r - R_d \qquad (1)$$

where R_r is the polarization resistance in the resting state, R_d is the polarization resistance at the crest of the rising phase and E_c is the difference between the altered resting potential and the potential at the crest of the rising phase. Or, assuming R_r and R_d are constant:

$$E_c = IR_r - IR_d + E_n \qquad (2)$$

Weidmann[2] has shown that in Purkinje fibres of the kid the ratio R_r/R_d is greater than 50, so that the term R_d could be neglected.

A typical relationship between I and E_c in a Purkinje fibre is shown in Fig. 1. There is some variation among these fibres; but all exhibit a curve, straight for values of E_c above 90–100 mV. and curved for lower values. In the former, the slope (dE_c/dI) equals R_r, whereas the steepening in the latter is the result of the additional effect of current on the activity of the sodium-carrying system[3], which, in our experiments, appears maximal at 90–100 mV.

In ventricular fibres, when positive and low negative currents are applied, the slope dE_c/dI varies widely from fibre to fibre. It is generally low and sometimes negative in value. This implies that R_d in equation (1) is of the same order as, and sometimes greater than, R_r. With negative currents greater than a certain value dE_c/dI yields predictable values for R_r 2–3 times smaller than for Purkinje fibres. During this phase R_d is now obviously much smaller than R_r. However, the plot of the amplitude of the action potential 2 msec. after the crest (shown in Fig. 1 by an interrupted line) has a negative slope indicating that the membrane resistance at this time is higher than R_r.

Thus the resistance at the crest of the ventricular action potential is normally of the same order as the resting resistance; whereas in Purkinje fibres the resistance at the crest is much lower, indicating that in ventricular fibres, if there is a sodium-carrying mechanism its activity has normally ceased well before the maximum height of the action potential is reached. This could explain the fact that: (1) the amplitude of the action potential of ventricular fibres (contrary to that of Purkinje) does not decline with reduction in external sodium concentration in the manner predicted by the sodium theory[4–6], and (2) in ventricular

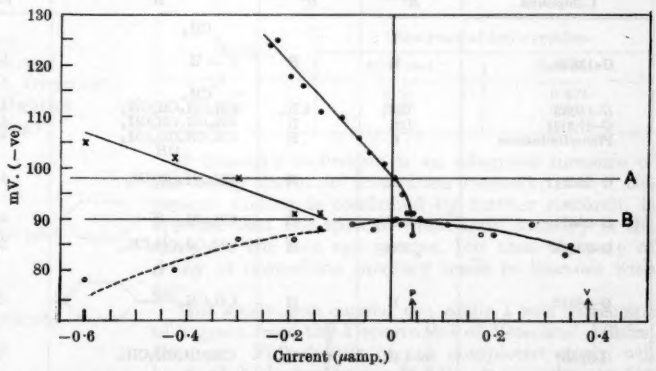

Fig. 1. Effect of current on the amplitudes of Purkinje and ventricular action potentials. Ordinate: action potential amplitude, E_c. Abscissa: current applied via stimulating barrel, +ve; depolarizing: −ve; hyperpolarizing. ●——●, Purkinje action potential; ○——○, ventricular action potential with positive and low negative currents; ×——×, ventricular action potential with high negative current; ○- - -○, ventricular action potential 2 msec. after the crest. *A* and *B* represent the normal amplitudes of Purkinje and ventricular action potentials respectively (that is, in the absence of applied current). *P* and *V* indicate Purkinje and ventricular threshold currents. In this particular experiment the polarization resistances (R_r) of the Purkinje and ventricular fibres were 100 k.ohm and 35 k.ohm respectively

fibres exposed to quinidine the maximum rate of rise of the action potential declines without a concurrent reduction in the amplitude[7].

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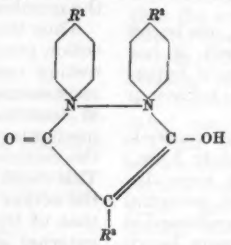
Relationship between pK_a and Uricosuric Activity in Phenylbutazone Analogues

Drugs which increase the urinary excretion of uric acid are of considerable value in the treatment of gout. Although it is fairly well established that these agents act by interfering with the reabsorption of uric acid by the renal tubular cells, the structural features required for this activity have not been defined. In the course of studies with one such drug, phenylbutazone, a relationship between chemical structure and uricosuric activity was noted. It was found that modifications in phenylbutazone, resulting in increased acidity of the molecule, are associated with enhanced uricosuric activity. However, changes which decrease the acidity of the drug are accompanied by loss of this activity.

In Table 1 are given the pK_a, relative uricosuric activity and biological half-life of a variety of analogues having modifications either in the benzene rings or the butyl side chain of phenylbutazone. The pK_a values were determined in dilute aqueous solutions by a method based on the differences in ultra-violet absorption of the ionized and un-ionized forms of the compounds[1]. The relative uricosuric potency of each compound is expressed in terms of the intravenous dosage required in gouty subjects to elicit a 100 per cent increase in the clearance ratio $C_{\text{uric acid}}/C_{\text{inulin}}$. The biological half-life of each drug was calculated from their rate of disappearance from plasma after single 600–800 mgm. intravenous doses.

In Table 1 the various analogues are arranged in order of increasing acid strength. The *iso*propyl analogue (*G*–13838) and the *p*-dimethyl analogue (*G*–15235), the weakest acids in the series, had no detectable uricosuric effect in intravenous doses of 1,200 mgm. Phenylbutazone and *G*–27202 required 800–1,000 mgm. intravenous doses to elicit a 100 per cent change in uric acid clearance whereas *G*–28231

Table 1. pK_a and Uricosuric Activity of Phenylbutazone Analogues



Compound	R^1	R^2	R^3	pK_a	Dose of drug for uricosuric effect (mgm.)*	Half-life (hr.)
G–13838	H	H	$CH(CH_3)_2$	5·5	No effect with 1,200	72
G–15235	CH_3	CH_3	$CH_2CH_2CH_2CH_3$	4·9	No effect with 1,200	48
G–27202†	OH	H	$CH_2CH_2CH_2CH_3$	4·7	800–1,000	72
Phenylbutazone	H	H	$CH_2CH_2CH_2CH_3$	4·5	800–1,000	72
G–28231†	H	H	$CH_2CH_2CH(OH)CH_3$	4·0	150–300	8
G–25671	H	H	CH_2CH_2–S–C$_6$H$_5$	3·9	150–300	3
G–28234	NO_2	H	$CH_2CH_2CH_2CH_3$	3·2	30–100	36
G–28315	H	H	CH_2CH_2–S(=O)–C$_6$H$_5$	2·8	30–70	3
G–32567	SO_2CH_3	SO_2CH_3	$CH_2CH_2CH_2CH_3$	2·7	100–150	1
G–30249	OH	H	C(=O)–CH$_2$–C$_6$H$_5$	2·0	30–70	3

* The intravenous dose required to elicit a 100 per cent increase in $C_{\text{uric acid}}/C_{\text{inulin}}$. The compounds were administered to gouty subjects by slow sustained infusion as described previously (refs. 2 and 3).
† *G*–27202 and *G*–28231 are metabolites of phenylbutazone in man (ref. 4).

and *G*–25671 produced this effect in doses ranging from 150 to 300 mgm. However, *G*–28315 and *G*–30249, two of the strongest acids, were active in doses as low as 30 mgm. Further experiments were carried out to determine the maximum uricosuric effect produced by the rapid injection of a single large dose of drug. For example, the rapid injection of 800–1,000 mgm. of either phenylbutazone or *G*–27202 increased the ratio $C_{\text{uric acid}}/C_{\text{inulin}}$ two- to three-fold, whereas the injection of 400 mgm. doses of either *G*–28315 or *G*–28234 increased the clearance ratio seven- to eight-fold. In addition, the oral administration of 800 mgm. doses of phenylbutazone and *G*–27202 produced about a 30 per cent increase in the daily excretion of uric acid over the control values, whereas the same dose of *G*–28315 and *G*–28234 produced about a 125 per cent increase.

The values obtained for the half-life of the various analogues rule out the possibility that the weakly uricosuric analogues may be metabolized or excreted too rapidly to achieve effective plasma levels. The compounds which had the most potent uricosuric effect, such as *G*–28315 and *G*–30249, actually disappeared at a considerably more rapid rate (half-life 3 hr.) than phenylbutazone, *G*–27202, *G*–15235 and *G*–13838 (half-life 2–3 days). The larger dose of *G*–32567 required to produce the uricosuric effect than that needed for *G*–28315 and *G*–28234 may be due to its extremely rapid disappearance (half-life 1 hr.).

The potent uricosuric activity of the highly acidic phenylbutazone analogues indicates that these drugs act in the ionic form to block the reabsorption of uric acid by the renal tubule cells, thus furnishing a possible clue to the still obscure nature of the transport mechanisms involved. The demonstration that uricosuric activity in the phenylbutazone series is related to the pK_a, has proved of considerable aid in searching for new uricosuric drugs. One such drug, *G*–28315, has already been found to be useful clinically as a potent uricosuric agent in treatment of gout[2,5,6].

We are grateful to Dr. Franz Haefliger and his colleagues of Geigy Pharmaceuticals, Basle, Switzerland, for the synthesis of the various phenylbutazone analogues used in this study.

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Decay of Immediate Memory with Age

Current theory tends to emphasize the importance of interference in forgetting and to minimize the role of time lapse in the decay of the memory trace. Conrad[1], however, has recently shown that the immediate recall of eight-digit numbers is better when the numbers are presented and reproduced by subjects at a fast rate than when they are presented and reproduced at a slow rate. He interprets this finding as indicating that simple decay of the memory trace is an important factor in the loss of immediate memory.

In the course of a more complex investigation of the relation between age and ability to retain for short- and long-term periods various classes of material, I tested two groups of subjects for their ability to retain eight-digit numbers when presented and reproduced at different rates. Group *A* consisted of 26 teachers, aged 18–29, drawn from different regions of Canada. Group *B* consisted of 26 teachers, aged 30–55, also drawn from different regions of Canada, and matched as closely as possible with Group *A* in general background, marks on university summer-school courses, and tests of remembering.

The results confirmed Conrad's finding that immediate recall is better when the numbers are presented and reproduced by subjects at a fast rate (120 digits per min.) than when they are presented and reproduced at a slow rate (40 digits per min.). The mean fraction of digits recalled at the slow rate was 0·475, and at the fast rate 0·543. These scores are both better than those reported by Conrad, but the samples in the present experiment are probably drawn from populations of higher intelligence, and the rates of presentation are slightly faster than in Conrad's experiment, both factors being likely to improve the scores on an immediate memory task.

Analysis of the results shows that there is no significant difference between the two groups in the proportion of digits recalled at the fast rate, but that there is a significant difference between the two groups ($P = 0{\cdot}05$) in the proportion of digits recalled at the slower rate. The actual figures are given in Table 1.

Table 1

Group	Proportion of digits recalled	
	Slow rate	Fast rate
A	0·51	0·575
B	0·37	0·58

If Conrad's technique is an adequate measure of the decay factor in immediate memory, and if the present finding is confirmed by further research, it appears that the span of immediate memory is the same for the two age groups, but that the rate of decay of immediate memory tends to increase with age.

This study was carried out while I was in receipt of a grant from the Department of Veterans' Affairs, Ottawa. Full details of the completed study will be published elsewhere. My thanks are due to Dr. J. M. Blackburn for his interest and encouragement.

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Comparison of the Tendency to cling to Glass and Hæmagglutination produced in Erythrocyte Suspensions by Ferric Chloride and by Influenza Virus

In a recent publication[1] dealing with the mechanism of virus hæmagglutination, it was suggested that erythrocytes that had adsorbed the virus became hydrophobic, hence their tendency to cling to glass. This hydrophobic character of the virus – erythrocyte adsorption complex produces behaviour similar to that observed with oil droplets in an aqueous medium. That is, under the influence of surface tension the complex adheres to any surface with which it is in contact. It was further suggested that the aggregation of erythrocytes (hæmagglutination), as well as tendency to cling to glass (shield formation), could be explained in this fashion without the necessity of postulating virus 'bridges'[2] linking cell to cell and cell to glass.

Some further studies have been performed by treating the erythrocytes with ferric chloride and comparing the ability of these cells to cling to glass beads with the similar ability of cells treated with virus or virus plus a cationic surfactant. The addition of a cationic surfactant enhances the ability of virus to produce the tendency to cling to glass.

The treatment with ferric chloride involved diluting a solution of 0·5 *M* $FeCl_3.6H_2O$ containing 20·0 ml. of concentrated hydrochloric acid per litre with isotonic saline, just prior to use, to yield a concentration of 100 μgm./ml. Ferric chloride prepared in this manner yields no colour when treated with *o*-phenanthroline and gives an opalescent solution the opalescence of which gradually increases. Both facts suggest that a colloidal suspension, or a suspensoid, rather than a solution is produced.

With both ferric chloride and virus, the erythrocytes and the respective agglutinin were mixed to yield a final volume of 5·0 ml. Changes in optical density of the mixture at 540 mμ were followed and when no further changes were observed, or at least 15 min. had elapsed, 50·0 mgm. of glass beads with a mean diameter of 60μ were added. Before use these beads were washed in acid and repeatedly rinsed with distilled water. After addition of the beads, the tubes were inverted several times, the beads allowed to settle, and the optical density of the erythrocyte suspension was determined. This was repeated until the optical density remained constant. When erythrocyte suspensions without added agglutinin are treated in this fashion no change in optical density occurs when the glass beads are added; nor is any change observed when the erythrocyte suspension contains virus or virus plus 4 μgm./ml. of cationic surfactant. The results obtained when ferric chloride is added are presented in Fig. 1. In this case the erythrocytes cling to the beads and are carried down with them. In addition, a more drastic hæmagglutination is produced by the ferric chloride.

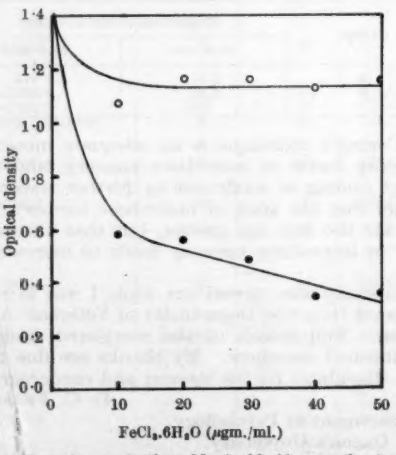

Fig. 1 Effect of concentration of ferric chloride upon the stability of a suspension of human erythrocytes in the presence or absence of glass beads. ○—○, Samples before adsorption with glass beads; ●—●, samples after adsorption with glass beads

These observations suggest that the forces responsible for virus hæmagglutination and the tendency to cling to glass are considerably weaker than those operating when ferric chloride is the agglutinin. In the latter case these forces would presumably be chemical bonding forces, or electrostatic interactions, or both. Thus, the observations are consistent with the postulate that surface tension, rather than virus 'bridges', underlies hæmagglutination and 'glass cling' of the virus – erythrocyte combination. Further support for this contention can be drawn from the study of electrostatic effects in virus hæmagglutination reported by Shingu[3].

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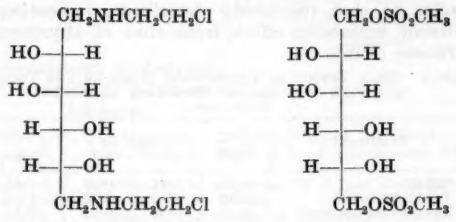
Tumour-inhibiting Action of I : 6-Dimethanesulphonyl-D-mannitol

Extensive clinical experience with 'Myleran' (I, $n = 4$) in the treatment of chronic myeloid leukæmia[1] has shown that when over-dosage is avoided the drug is free from side-effects. On the other hand, other alkylating agents which are used clinically, namely, ethyleneimine derivatives and nitrogen mustards, usually cause some side-effects. This contrast may be attributable to a different mechanism of action for 'Myleran' and for the other alkylating agents. Evidence for this difference arises from comparison of the effects of 'Myleran' and a mustard (chlorambucil) on rat bone-marrow[2] and from a similar comparison where, when the drugs were used clinically in leukæmia, there was no enhanced excretion of uric acid after administration of 'Myleran' although nitrogen mustards and triethylenemelamine caused a significant rise in uric acid excretion[3]. 'Myleran' and its congeners (I), while they inhibit experimental tumours, cause a marked depression of bone-marrow function and cannot therefore be considered suitable for the treatment of solid tumours in man. In the 'Myleran' series there is evidence that variations in neutrophil-depressing and also in tumour-inhibitory activity may depend very much on the ratio between the solubility of the particular compound in water and in ether[4]. In the hope that a very large relative increase in water solubility might possibly minimize the bone-marrow depressing properties of the 'Myleran' series while leaving unaffected tumour-inhibitory activity together with the apparent clinical

virtues attributable to the 'Myleran' type of action, we decided to modify the series by the insertion of hydroxy groups in the polymethylene chain. *Bis*-1:6-2′-chloroethylamino-1:6-dideoxy-D-mannitol (II) had been made because it was a type of nitrogen mustard which it was thought might inhibit glycolysis[5]. The fact that its tetrahydroxylated hexamethylene chain structure was consistent with tumour-inhibiting activity led us to choose 1 : 6-dimethanesulphonyl-D-mannitol (III) as the first member of our new series.

$$CH_3SO_2O(CH_2)_nOSO_2CH_3$$

(I)



(II) (III)

1 : 6-Dimethanesulphonyl-D-mannitol was first prepared by the reaction of 1 : 2-5 : 6-dianhydro-3 : 4-*iso*propylidene-D-mannitol with methanesulphonic acid, in ether solution. As we expected, the two epoxide rings were split and addition of 2 mol. of methane sulphonic acid occurred, but the *iso*propylidene residue then evidently became highly labile and was lost by hydrolytic splitting in the presence of a trace of water taken up by the ether in the course of the experiment. The structure assigned was unequivocally shown to be correct by synthesis via benzylidenation of 1 : 6-dibenzoyl-D-mannitol, followed by debenzoylation, mesylation, acetolysis and methanolysis.

Under biological test, 1 : 6-dimethanesulphonyl-D-mannitol combines relatively low toxicity with powerful inhibition of the growth of the Walker rat carcinoma-256, and of a radiation-induced rat lymphatic leukæmia. Substantial inhibition has also been observed in the case of the exceptionally resistant 'August' rat carcinoma.

The investigation has been supported by grants to this Institute from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

Note added in proof. Since submitting this communication, we have simplified the preparation of the drug by showing that successive treatment of D-mannitol with 2 mol. of methanesulphonyl chloride and 4 mol. of acetic anhydride in pyridine solution yields its tetracetyl derivative.

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Forssman's Antigen in Ehrlich Mouse Carcinoma

The question of whether a specific antigen exists in cancer tissue is receiving increasing attention. The view generally held is that carcinoma contains Forssman's[1] antigen.

Injection of rabbits with a cell suspension prepared from transplantable Ehrlich's mouse carcinoma gives rise to the formation of heterogenetic Forssman antibodies[2]. But two forms are known of Ehrlich's carcinoma; (*a*) the solid tumour formed after subcutaneous inoculation, and (*b*) the ascites tumour seen after intraperitoneal injection.

Our investigation was made with the 'classic' Ehrlich transplantable tumour strain, which was placed at our disposal by Dr. Eva Melander, Institute of Genetics, University of Lund, Sweden.

By immunizing rabbits with cell suspensions of solid Ehrlich carcinoma we had no trouble in confirming Morgenroth's[3] statement; but with the ascites carcinoma we could not reproduce his findings; Forssman's antibodies could not be induced by injecting rabbits either with cells and liquid withdrawn from the peritoneal cavity of inoculated mice, or with cells or liquid separated by centrifuging.

The action of rabbits' sera was judged by their power to lake 5 per cent suspensions of sheeps' red blood corpuscles in the presence of complement. Examples of several tests, all with similar results, are shown in Table 1.

Table 1

Rabbit's serum	Hæmolytic titre	
	Before immunization	After immunization
Anti-Ehrlich carcinoma	1 : 100	1 : 4000
,,	1 : 10	1 : 2000
,,	1 : 10	1 : 1000
Anti-ascites carcinoma	1 : 50	1 : 100
,,	1 : 200	1 : 100
,,	1 : 50	1 : 50
Anti-ascites carcinoma cells	1 : 100	1 : 100
,,	1 : 50	1 : 20
,,	1 : 20	1 : 50
Anti-ascites carcinoma liquid	1 : 200	1 : 200
,,	1 : 100	1 : 50
,,	1 : 100	1 : 100

These results make one doubt whether Forssman's antigen is, in fact, a component of the Ehrlich mouse cancer cells at all. But this was confirmed by the following experiments.

Sera with known heterogenetic antibody content (anti-guinea pig kidney serum, and anti-sheep red-cell serum) were absorbed with either Ehrlich carcinoma or ascites carcinoma cells. Ehrlich carcinoma cells invariably suppressed the hæmolytic titres of these anti-Forssman sera. Ascites carcinoma cells, on the other hand, failed to do so.

Alcoholic extracts of both types of cell suspension were then prepared. Those of the Ehrlich carcinoma cells produced clear-cut ring reactions with the anti-Forssman sera when tested by Sachs and Guth's method[3]. Alcoholic extracts of the ascites carcinoma-cells invariably failed to react.

Ascites carcinoma, unlike Ehrlich carcinoma, appears to be free of heterophilic antigen. This seems surprising: (*a*) because the mouse is a Forssman's antigen-bearing animal, and (*b*) in view of the generally held opinion that cancers contain heterophilic antigen, even in Forssman-negative species.

Further consideration, however, shows that the histological structure of the two carcinomas differs in that Ehrlich carcinoma is rich in fibroblasts and capillaries; it has a rich stroma of mesodermic origin. Ascites carcinoma, on the other hand, consists of epithelial carcinoma cells with no other component except the peritoneal fluid suspending the cells. This certainly suggests that it is the stroma part of the solid tumour, and not the carcinoma cells as such that carries the heterophile antigen. This supposition finds support in a paper by Tanaka and Leduc[5], in which they state that Forssman's antigen in various normal organs of Forssman-positive species (guinea pig, mouse) is present mainly in the connective-tissue structures, and not in the parenchyma; it was located microscopically by the fluorescent antibody method. Although no similar data are as yet available concerning cancer tissues, this may prove to be correlated with our own findings. It should be possible to confirm this by the same technique[6].

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Differences between the Early Metabolic Effects of Thyrotropic Hormone and Triiodothyronine

The physiological significance of triiodothyronine is still uncertain[1]. In previous reports[2,3] rapid metabolic changes, possibly of thyroid origin, have been described in association with emotionally stressful life experiences in man. An investigation was therefore undertaken to see how soon metabolic changes could be demonstrated following triiodothyronine and thyrotropic hormone.

Observations on metabolic rate, pulse-rate, blood pressure and various urinary constituents were made at 2-hr. intervals for a period of 8 hr. in five healthy volunteer medical students following triiodothyronine (kindly supplied by Glaxo Laboratories) (0·5 or 1 mgm.) given intravenously as a single injection, and thyrotropic hormone ('Thytropar', kindly supplied by Armour and Co., Chicago) (0·44 U.S.P. units/kgm. body-weight) given intramuscularly. As a control observations were made following the intramuscular injection of saline. All studies were made in the fasting state using techniques previously described[4].

The rise in metabolic rate was greater with thyrotropic hormone than with triiodothyronine ($P < 0·01$). The elevation with triiodothyronine was barely significant within this time ($P = 0·07$) (Table 1).

Table 1. Mean Effect of Thyrotropic Hormone and Triiodothyronine on Metabolic Rate
(cal./sq.m./hr.)

Treatment	Time (hr.) 1	3	5	7
Saline	39·5	39·9	41·3	42·3
Triiodothyronine	38·9	40·7	42·1	43·7
Thyrotropic hormone	38·0	40·8	44·2	46·2

The associated elevation of pulse-rate with thyrotropic hormone was significantly greater than with triiodothyronine ($P < 0·01$) which did not differ from the control; elevation of pulse pressure was also observed following thyrotropic hormone but not following triiodothyronine. Significant elevation of serum protein-bound iodine has been previously noted within 4 hr. following thyrotropic hormone in similar dosage[6].

However, triiodothyronine produced a greater increase in inorganic phosphate excretion ($P < 0·025$), similar to that previously described[4], indicating a different metabolic effect from that of thyrotropic hormone (Table 2).

Table 2. Mean Effect of Thyrotropic Hormone and Triiodothyronine on Inorganic Phosphate Excretion
(mgm./min.)

Treatment	Time (hr.) 0–2	2–4	4–6	6–8
Saline	0·39	0·47	0·53	0·53
Triiodothyronine	0·46	0·46	0·80	1·04
Thyrotropic hormone	0·37	0·49	0·55	0·47

Transient increases in sodium and potassium excretion within the first 4 hr. were noted following thyrotropic hormone ($P < 0·05$) but not following triiodothyronine.

The specificity of these changes following thyrotropic hormone was confirmed when it was given in similar dosage to a series of five hypothyroid subjects on maintenance dosage of desiccated thyroid (Table 3).

Table 3. Mean Effect of Thyrotropic Hormone on Metabolic Rate in F.V.I. Hypothyroid Subjects on Thyroid
(cal./sq.m./hr.)

Treatment	Time (hr.) 1	3	5	7
Saline	34·4	33·6	35·1	36·3
Thyrotropic hormone	34·1	34·2	36·0	36·9

The effect of thyrotropic hormone on the metabolic rate was significantly less than in the normal subjects ($P < 0·001$); the rise in pulse-rate was also less ($P = 0·07$); no increase in sodium and potassium excretion occurred. The mean increase in metabolic rate was proportionately greater in the normal subjects (21·6 per cent) than in the hypothyroids (8·3 per cent).

These findings suggest that the early effect of thyrotropic hormone differs from that of triiodothyronine but is still of thyroid origin. They support previous suggestive evidence obtained from observations made during emotionally stressful life experiences in man[2,3] of a rapidly active thyroid hormone distinct from triiodothyronine.

In this connexion it is of interest that the calorigenic effect of desiccated thyroid is greater than that indicated by its 'thyroxine iodine content'[8]. Similar findings have been reported with thyroglobulin[7,8]. Such discrepancies appear to be too great to be accounted for by the minute amounts of triiodothyronine recovered from the thyroid[9].

In a recent chromatographic study no increase in triiodothyronine could be demonstrated in the plasma following thyrotropic hormone in euthyroid subjects[10].

The observations reported here indicate that the early metabolic effect of the thyroid secretion under stimulation by thyrotropic hormone is not accounted

for by triiodothyronine. They provide evidence of a rapidly active thyroid hormone distinct from triiodothyronine as previously suggested[5].

Further investigations are in progress and more detailed findings will be published elsewhere.

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An Anticlumping Factor for Mitochondria in the Supernatant Fraction of Rat-Liver Homogenates

In a rat-liver homogenate that has not been strongly diluted the mitochondria remain substantially unclumped for several hours even at room temperature; but if it is diluted more than about five-fold with a medium containing electrolyte, serious clumping may occur in a few minutes. If it is diluted with the supernatant from another homogenate which has been only slightly diluted, clumping is almost completely inhibited. This shows that a natural anticlumping factor is present in the supernatant. The factor is thermolabile, non-dialysable and precipitable from supernatant by half-saturated ammonium sulphate. Its activity is lost gradually at 0° C. but is retained indefinitely at − 15° C. The lability suggests that it is not identical with heparin, which is known to prevent mitochondrial clumping. This is confirmed by the fact that our factor does not, like heparin, produce nuclear haloes[1] by combining with histone and liberating deoxyribonucleic acid. On the other hand, all its properties known so far correspond with those of the ribonuclease inhibitor discovered by Roth[2,3], which is also not identical with heparin although the latter inhibits ribonuclease. We therefore tested crystalline pancreatic ribonuclease for clumping activity and found it very potent in absence but not in presence of supernatant, as expected. Thus there is good reason for accepting as a working hypothesis that our anticlumping factor and Roth's ribonuclease inhibitor are identical, though this can be established with certainty only by isolation of the two substances. Our factor, like Roth's, varies greatly in concentration in apparently similar preparations. One supernatant had perceptible anticlumping activity at a dilution of 1/180, suggesting that even crude concentrates of the factor will be useful protectors in any experiments where mitochondria need to be kept in good condition.

The quantitative assessment of mitochondrial clumping is not easy. We tried various indices, for example the ratio of total clumps (including single mitochondria) to total mitochondria, or the number of mitochondria in the largest clump in a field. Finally, we made a scale consisting of nine numbered photographs of mitochondria clumped by incubation with ribonuclease for varying times, and chosen so that the general impression of clumping in adjacent photographs was just perceptibly different (Fig. 1). Other photographs were then assigned 'clumping numbers' from 0 to 8 by matching against the standards. This principle, whereby the scale unit is defined in terms of the unit of subjective discrimination, is the basis of the well-known Munsell colour scale[4] and was used by Bourdillon and his co-workers[5] in assessing rickets in rats.

A rough test of accuracy was performed by asking eleven judges, separately, to place the nine standard photographs in order. Comparing their rankings with the expected order, it was found that no judge displaced the rank of any photograph by more than ± 2 units and that such displacements occurred in only three of the 99 cases. The greatest mean displacement of a photograph, averaging over the eleven judges, was 0·36 unit. The distribution of the 99 displacements was [see over]:

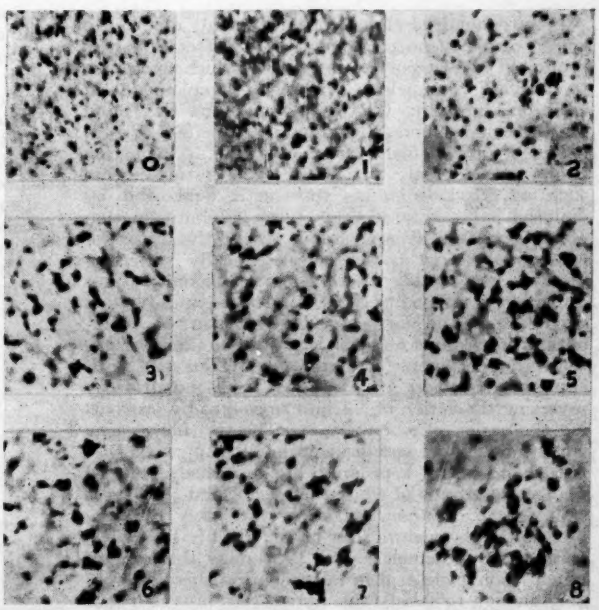

Fig. 1. Photographic scale for assessment of mitochondrial 'clumping number'

Displacement units	−2	−1	0	+1	+2
Frequency	1	13	72	11	2

The distribution is leptokurtic. The root-mean-square displacement is 0·6 unit. The coefficient of concordance[6] is 0·95 and is highly significant. Thus there is a marked measure of agreement between the rankings of the eleven judges, and their average judgment agrees with the expected order. The use of clumping numbers to demonstrate the clumping action of ribonuclease and the anti-clumping action of liver supernatant is shown in Fig. 2. The amount of supernatant used in this experiment gave 98 per cent inhibition of the breakdown of added ribonucleic acid by the same amount of ribonuclease.

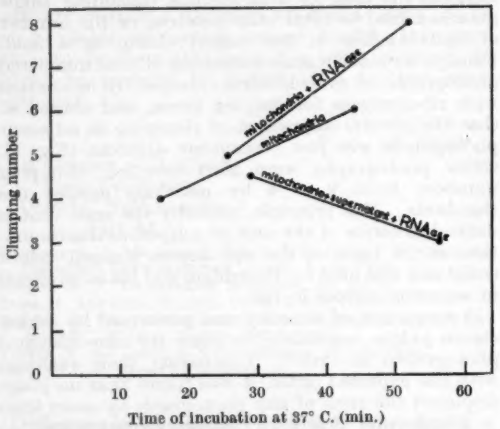

Fig. 2. Enhancement of clumping of mitochondria by added ribonuclease, and protection by supernatant. The mitochondria were washed with and suspended in 0·3 *M* sucrose, 0·1 *M* sodium chloride, 0·01 *M* potassium phosphate pH 7·8, with the addition of 0·05 γ/ml. crystalline pancreatic ribonuclease (top line) or 0·005 γ/ml. ribonuclease + liver supernatant at a dilution of 1/180 (bottom line)

If mitochondrial clumping is commonly due to the action of endogenous ribonuclease, the fact that it is promoted by electrolytes in general, which are known to activate ribonuclease[7], is readily explained. In addition, however, the divalent cations Ca^{2+} and Mg^{2+} seem to have a clumping action out of proportion to their effects on ribonuclease. This action seems to be partly reversible by chelating agents such as ethylenediamine tetraacetic acid, and by dialysed half-saturated ammonium sulphate fraction of supernatant. We therefore tested the latter for calcium chelating power colorimetrically with ammonium purpurate. Although the technique was imperfect it sufficed to show that the calcium-binding capacity of the anti-clumping fraction of supernatant per atom of nitrogen is about five times greater than that of whole supernatant. Thus the anti-clumping fraction may protect mitochondria by reversing the action of calcium as well as by preventing the action of ribonuclease. The two phenomena can be explained simultaneously by supposing that mitochondria are kept apart by negatively charged phosphate groups of ribonucleic acid, and that these charges can be abolished either reversibly by combination with calcium ions or irreversibly by hydrolysis of the ribonucleic acid. Although there is not much ribonucleic acid in mitochondria there is probably enough to satisfy this hypothesis, provided that it is mainly at the surface.

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Hyperglycæmia induced in Rabbits by 5-Hydroxytryptophan

Administration of large doses of 5-hydroxytryptophan (60–100 mgm./kgm.) to rabbits produces marked central effects, for example, mydriasis, hyperpnœa, tachycardia, tremor and ataxia[1,2]. These effects seemed to be similar to those observed after giving lysergic acid diethylamide[1]. As lysergic acid diethylamide very markedly raises the blood-sugar level in the rabbit by a central action[3,4], 5-hydroxytryptophan should also produce hyperglycæmia if its central effect is similar to that of lysergic acid diethylamide.

Blood-sugar measurements were made using the modified method of Shaffer and Hartmann[5] in the blood of the ear artery of rabbits. It was found that 5-hydroxytryptophan given intravenously in small doses (5–20 mgm./kgm.) definitely raised the blood-sugar level. Fig. 1 shows the blood-sugar rise after 10 mgm./kgm.; Fig. 2 shows the dose–response curve, plotted on a logarithmic scale.

5-Hydroxytryptophan had to be given in doses at least 200 times higher than those of lysergic acid diethylamide to produce a comparable hyperglycæmic effect. 5-Hydroxytryptophan was also much weaker than lysergic acid diethylamide in producing a rise in body temperature (see ref. 6). Unlike lysergic acid diethylamide, however, 5-hydroxytryptophan elicited a hyperglycæmic effect when smaller doses were given than those required to produce an increase in body temperature[6].

During aprobarbital anæsthesia it was not possible to elicit hyperglycæmia with 5-hydroxytryptophan (20 mgm./kgm.). This suggests a central effect as

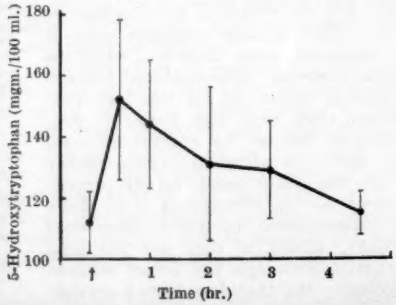

Fig. 1. Hyperglycæmic action of 10 mgm./kgm. 5-hydroxytryptophan (given intravenously at †). The vertical lines indicate the standard deviation of results obtained from nine animals ($P < 0{\cdot}001$ for the highest value)

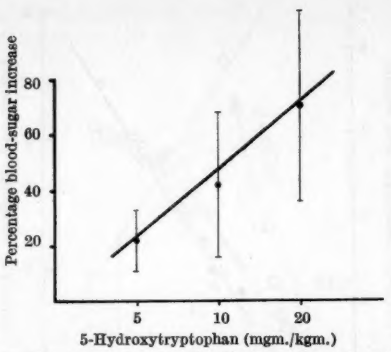

Fig. 2. Dose response curve for the hyperglycæmic action of 5-hydroxytryptophan administered intravenously. The mean response to 5 and 10 mgm./kgm. was established in nine animals, to 20 mgm./kgm. in six. The vertical lines indicate the standard deviation of results. Statistical calculation showed that the regression line did not depart significantly from linearity

in the case of lysergic acid diethylamide, whereas the blood sugar increase due to the peripheral action of adrenaline does occur under aprobarbital.

The hyperglycæmic effect of 5-hydroxytryptophan, which is the precursor of 5-hydroxytryptamine, may be of interest since 5-hydroxytryptamine can, under certain conditions (depancreatized dogs), produce a rise in blood sugar[7] and since the pancreas exhibits a high degree of 5-hydroxytryptophan-decarboxylase and mono-amino oxidase activity[8].

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Lathyrism in Mice

It is known that rats fed on a diet containing 50 per cent sweet-pea (*Lathyrus odoratus*) seed develop severe bony deformities, and that if young animals are used a proportion die of rupture of the aorta[1,2]; β-amino-propionitrile has a similar effect[3]. Few workers had previously attempted to produce lathyrism in mice, and their reports suggested that mice were refractory. Preliminary experiments, however, showed that aortic lesions in mice could be obtained, and while this work was in progress Dasler and Milliser[4] reported the production of aortic lesions in male weanling mice by feeding them on *L. odoratus* seeds; injection of high doses of β-amino-propionitrile gave, in addition, bony lesions. Experiments were continued with the aim either of confirming Dasler and Milliser's work and producing lathyrism in a cheap and easily handled animal or, if the mouse were resistant, of using this difference in response between two such closely related species as the rat and the mouse for investigation of the pathogenesis of lathyrism.

Porton mice were used, and either fed on a diet containing sweet-pea seed or injected with β-amino-propionitrile. The diet consisted of 40–50 per cent *Lathyrus odoratus* seed, finely ground, mixed with ground rat-cake (diet 86) and reconstituted into cubes with water; β-amino-propionitrile was given as the hydrochloride by subcutaneous injection of a 1:10 solution in distilled water; dosage was approximately 0·1 ml./10 gm. body-weight.

In all 200 mice were treated. In 152 treatment started either *in utero* or in the suckling period. Thirty mice from various litters were eaten or unfit for histology; in addition, four entire litters of mothers treated during pregnancy were destroyed by the mothers, and are not included. Forty-five mice which either died or were killed before the age of two weeks were examined: all had histological lesions of the aorta, and approximately half had aortic rupture. In 77 mice, treatment was continued either *per os* or by injection for a varying period after weaning: in 53 aortic lesions were present. Thirty-three mice started treatment when between 2 and 5 weeks of age (injected or weaned on to the sweet-pea diet): seventeen had histological lesions. Fifteen mice started treatment when more than 8 months old: none had significant lesions.

The aortic lesions can conveniently be divided into two main groups. In all infant mice treated *in utero* or in the first few days of life by feeding or injecting the mother there is a characteristic change in the elastica, which is thinned and often interrupted. A proportion of the young die—some of aortic rupture. These experiments show clearly that the toxic principle passes the placenta and is also excreted in the milk.

In the older mice, thinning of the elastica is not observed. Instead, there is rupture of elastic laminæ ranging in severity from rupture of individual laminæ to total rupture of the aorta. Rupture of individual laminæ is occasionally seen in untreated old mice, but not in young animals.

As in rats, aortic lesions are produced only in young animals, though the dosage required to produce aortic lesions in mice is higher. The period of maximum susceptibility was found to extend from the last week of intra-uterine life to the fifth week of post-natal life. Within these limits the younger the animal the easier it is to produce lesions. If treatment is given to the mother during the first two weeks of pregnancy and then stopped, the young are born healthy, though histologically the elastica is abnormal, particularly the outer layers, which are thinned. Treatment started after 5 weeks of age has no effect.

A difference in the susceptibility of the sexes has not been reported in rats, whereas in mice sex markedly affects results. When treatment is given *in utero* or in the first few days of life, both sexes are affected. However, if started at 2 weeks of age or later, aortic damage occurs predominantly in the male. It is noteworthy that Dasler and Milliser[4] used only male mice, and it seems probable that had they used mice of both sexes they would have produced fewer aortic lesions. Again, in contrast with the rat, mice do not develop bony lesions with the dosage I have used.

Menzies and Mills[5] suggested that in rats the primary lesion is in the ground substance, and that proliferation of fibroblasts precedes elastic damage. The histology in mice shows clearly that, in infant mice at least, there is an alteration in the elastica before any increase in ground substance can be recognized. Also, in sections from adult mice, rupture

of elastic fibres is frequently seen in the absence of any fibroblastic proliferation. Lastly, no alteration in the muscle cells is apparent in any of the sections. This leaves the elastica as the element primarily affected.

The fact that the period of susceptibility coincides with the period of maximum growth suggests that the condition is not one of degeneration of the elastica but rather of malformation.

My thanks are due to Dr. G. W. Crosbie of the Biochemistry Department, University of Glasgow, for preparing the β-amino-propionitrile.

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Day-length and Hæmatin Compounds in Plants

It has been shown that day-length regulates the chlorophyll content of many plants[1–3] and that this is a true photoperiodic phenomenon[4]. In leguminous plants, day-length controls both the chlorophyll content and the number and efficiency of the root nodules[5,6]. It seems that, in this case, both the synthesis of hæmoglobin in the nodules and the synthesis of chlorophyll in the leaves are depressed by short day-length. Moreover, there are indications that in some plants (tobacco, for example), the ratio between the quantity of chlorophyll and the quantity of total hæmatin in the leaves remains constant over a wide range of concentrations (Davenport, H., personal communication).

I therefore thought it of interest to investigate whether day-length influences hæmatin-content as it does chlorophyll-content. I studied simultaneously the chlorophyll and total hæmatin during long-day (16 hr.) and short-day (8 hr.) in four species: soya bean (*Soja hispida*), lupin (*Lupinus albus*), wild strawberry (*Fragaria vesca*), and hemp (*Cannabis sativa*). Total hæmatin was measured by the method of Hill and Scarisbrick[7]. Chlorophyll was measured with the Beckman spectrophotometer in 80 per cent acetone using the formula of Mackinney[8].

As shown in Fig 1, in mature leaves there was generally a constant molar ratio of about 60 molecules of chlorophyll to 1 molecule of hæmatin.

In the leguminous plants, soya bean and lupin, the ratio remains constant on changing from long to short days and vice versa. Short-day treatment reduces the hæmatin- and chlorophyll-content of the leaves simultaneously and to the same extent, while long-day treatment increases both. In the leaves, there is about 20–30 per cent less hæmatin during short-day than during long-day (Table 1). The decrease is not only evident in the leaves, but also in the roots. With the lupin, some nodules during short-day had a hæmatin-content 50 per cent lower than in the long-day control. These facts support the idea that, in the leguminous plants, the lack of nodule formation and efficiency in short-day is due to a general hæmatin deficiency, itself related to a marked depression of chlorophyll content in short-day. The occurrence of such a relation between hæmatin and

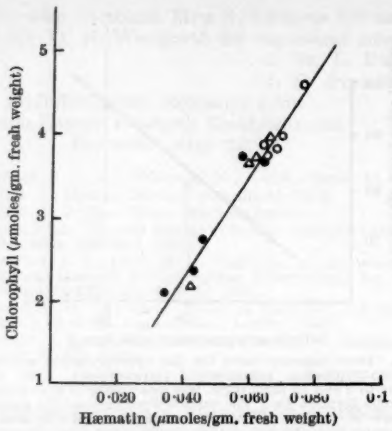

Fig. 1. Relation between hæmatin- and chlorophyll-content in mature leaves. (For lupin and soya bean, the different chlorophyll contents were obtained in different day-length conditions; for hemp, the figures are for long-day only.) ●, lupin; ○, hemp; △, soya bean

chlorophyll is particularly striking when one considers the photoperiodic control of flowering.

In wild strawberry, which does not flower when grown in short-day, we find a much lower hæmatin-content in the mature leaves in short-day than in long-day (in agreement with the decrease in chlorophyll content). But the opposite occurs in hemp, a plant in which flowering is immediately induced by short-day. A typical experiment is shown in Fig. 2. In long-day, hemp shows the normal molar ratio chlorophyll/hæmatin of about 60. If one transfers it at the stage of four expanded leaves from long- to short-day, the chlorophyll content immediately decreases[3]. In this particular case, however, instead of decreasing, the hæmatin content increases (the molar ratio chlorophyll/hæmatin drops to 30–40). In short-day, there is about 30 per cent more hæmatin than in long-day. The transformation is very rapid. It needs only five short days to show a significant effect in the fourth leaf. It is entirely reversible. After five short days, the transfer back to long-day leads to an increase of chlorophyll content and a decrease of hæmatin. The molar ratio chlorophyll to hæmatin returns to its normal value of 60. At the same time, induction of flowering stops.

Table 1. Effect of Day-length on Hæmatin Content in Lupin and Soya Bean
Hæmatin in μmoles/gm. fresh weight

Organs analysed	Day-length	Lupin			Soya bean	
		Series No.			Series No.	
		1	2	3	1	2
Adult leaves (*a*)	Long	0·058	0·046	0·065	0·060	0·066
	Short	0·043	0·035	0·037	0·046	0·043
Roots (*b*)	Long	0·017	0·014	0·011	0·016	—
	Short	0·012	0·010	0·007	0·008	—
Nodules	Long	0·270	0·144	—	—	—
	Short	0·124	0·083	—	—	—

(*a*) The following leaves have been analysed: in lupin, leaf No. 12 (series 1 and 2) and leaf No. 14 (series 3); in soya bean, leaf No. 1 (series 1) and leaf No. 2 (series 2).

(*b*) In lupin, the principal roots have been analysed; in soya bean the total roots including the secondary roots.

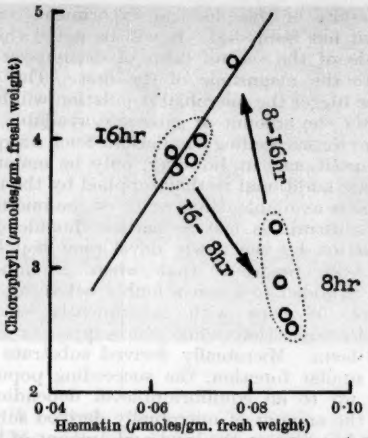

Fig. 2. Effect of transfer from long to short days and vice versa on chlorophyll/hæmatin ratio in hemp. (The arrows indicate directions of transfer; see text)

Further details of these experiments will be published elsewhere. I am greatly indebted to Dr. R. Hill for valuable help in the method of measuring hæmatin in leaves, to Prof. F. G. Young for providing facilities in the Department of Biochemistry, Cambridge, to Mr. J. Gilmour, director of the Botanical Garden, Cambridge, for growing the plants, and to the I.R.S.I.A. (Belgium) for financial support.

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Occurrence of Coumarin Analogues in Lemon Juice

There has been little or no investigation of coumarin compounds in lemon juice although their presence in lemon oil has been well established[1–4].

It was of interest to determine whether coumarin analogues were indeed present in lemon juice. Petroleum ether extracts of California lemon juice concentrates were examined by the chromatostrip technique of Miller and Kirchner[5]. This revealed a group of eight fluorescent spots suggestive of the coumarin array demonstrated by Stanley and Vannier[4,6]. Extracts were then subjected to downward chromatostrip development[6] and separation of four of the compounds was achieved in amounts adequate for qualitative ultra-violet spectral measurements. Comparison of R_F values with known coumarin compounds and ultra-violet absorption spectra tentatively identified these four compounds as 5-geranoxypsoralen (bergamottin), 5-geranoxy-7-methoxycoumarin, 8-geranoxypsoralen and 5,7-dimethoxycoumarin (limettin) (Table 1).

The possibility remained that the coumarin compounds detected in the juice could conceivably be present because of inclusion of lemon oil in the concentrate. This could come about during the mechanical reaming of the fruit resulting from the rupture of the oil sacs releasing small amounts of oil into the juice[7].

Table 1

Compound	$R_F \times 100$*	Ultra-violet absorption maxima (mμ)
5-Geranoxypsoralen	68	251, 259, 269, 310
5-Geranoxy-7-methoxycoumarin	64	246, 256, 325
8-Geranoxypsoralen	40	244, 250, 265, 300
5,7-Dimethoxycoumarin	25	246, 256, 325
Oxypeucedanin hydrate	5	250, 259, 268, 310
Byakangelicin	0	241, 249, 270, 313

* On silicic acid chromatostrips (refs. 5, 6). Irrigation solvent: 25 per cent ethyl acetate in *n*-hexane (v/v).

In order to determine whether these coumarin compounds were present in oil-free lemon juice the following experiment was performed.

Thirty-six lemons were thoroughly scrubbed and washed in a hot detergent solution and rinsed with water. The lemons were then allowed to soak in hot water for about 30 min.

The epicarp (flavedo) was carefully stripped from each fruit by means of a stainless steel knife, and the fruit rinsed in cool water. The mesocarp (albedo) and segment membranes of the fruit were then removed and the lemons quartered. Finally the central vascular bundle and all the seeds were removed.

The sectioned juice sacs were homogenized in a blendor for 15 min., and the homogenate filtered to remove any remaining membrane material. 250 gm. of this material were extracted with three 100-ml. portions of low-boiling petroleum ether, the extracts combined, dried over anhydrous sodium sulphate, filtered and the solvent removed under reduced pressure on a steam-bath. A pale yellow oil resulted. A small amount of the oil (about 0·01 ml.) was applied to a silicic acid chromatostrip[6] and irrigated with a solution of 25 per cent ethyl acetate in *n*-hexane. Examination of the strip under ultra-violet light (2540 A.) revealed eight distinct spots or zones.

Several downward chromatostrips[5] were run, the individual zones scraped from the strip, each eluted with 95 per cent ethanol and the eluates filtered. The ultra-violet spectrum of each eluate was then taken.

Comparison of R_F values with known coumarin compounds and ultra-violet absorption spectra tentatively identified five of these compounds as 5-geranoxypsoralen (bergamottin), 8-geranoxypsoralen, 5,7-dimethoxycoumarin (limettin), oxypeucedanin hydrate and byakangelicin (Table 1).

To date, insufficient amounts of these compounds have been isolated from the juice for more precise analytical examination; but this work is in progress.

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Further Aspects of Humus Decomposition

Recent experiments have shown that the characteristic flush of decomposition that follows the wetting of a dry soil can be partly prevented by the addition of 0·5 gm. of activated charcoal (per 30 gm. soil) and almost completely prevented by 1·5 gm. or more (Fig. 1). When the soils were then oven-dried and re-wetted without further treatment a similar result was obtained. When a slowly decomposing moist soil was treated with ether vapour under vacuum and the excess vapour then removed, a similar flush of decomposition resulted which was also repeated with successive treatments. Here, however, the flush of decomposition was not inhibited by charcoal.

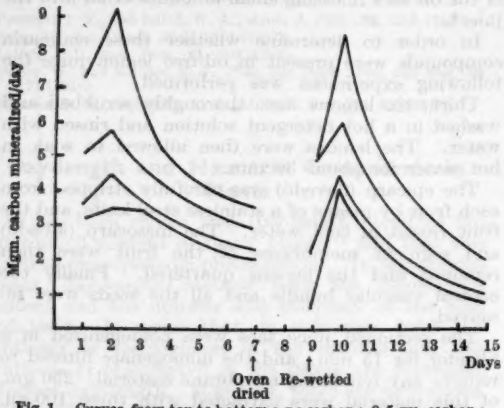

Fig. 1. Curves, from top to bottom: no carbon; 0·5 gm. carbon; 1·0 gm. carbon; 1·5 gm. carbon

These results afford an insight into the factors involved in humus decomposition and the partial sterilization of soils. Soil drying increases the amount of organic material later going into solution and when this is adsorbed by the charcoal the flush of decomposition is inhibited. Ether vapour has, however, been found here to have no effect on the amount of organic material that will dissolve. Nevertheless, the flush of decomposition still occurs and this may be ascribed to the high microbial activity associated with the youthful phase of the newly developing population and the presence of dead microbial cells which can serve as readily available substrate[1].

Since heat causes diffusion of amino-acids from within the cells[2], it is possible that the compounds adsorbed by the charcoal are amino-acids or similar microbially derived compounds and that these, serving as available substrate, are responsible for the flush of decomposition following the wetting of an oven-dry soil. Ether, on the other hand, reduces cell permeability[3] and was found here to be ineffective in increasing the amount of organic material going into solution. Charcoal, therefore, has no effect after ether treatment in inhibiting the flush of decomposition which must depend on the utilization of relatively intact dead cells as substrate. Clearly, the marked decomposition that follows partial sterilization is not necessarily dependent on increased solubility of substrate. The main factor involved appears to be microbial death, whether accompanied by lysis of the cell contents or not, the remains then serving as available substrate when normal conditions are restored. The newly developing population will also be more active at first than later on.

The results of the charcoal experiment conform with what has been said. It will be noted that the magnitude of the second flush of decomposition is related to the magnitude of the first. The larger this is the bigger the microbial population will be and the greater the amount of substrate available, after killing, for the succeeding population. Such a sequence of decompositions can, however, only be maintained if substrate additional to that supplied by the micro-organisms is available, since much of the microbially derived substrate is lost as carbon dioxide during its utilization by the newly developing population. It has been reported[4] that when decomposable material is added to a soil a highly active microbial population develops with consequently enhanced humus decomposition while the supply of energy material lasts. Microbially derived substrate could serve a similar function, the succeeding population building up to an equilibrium-level depending not only on the amount of microbially derived substrate available but also on the kind and amount of humus present. This would explain why the sequence of decompositions are of approximately equal magnitude and are also dependent on the carbon content of the soil.

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Chlorine Deficiency in Soils

In the past five years chlorine has been shown to be an essential micronutrient for a number of vegetable and crop plants[1,2]. More recently, the need for chlorine was demonstrated in the annual pasture plant, subterranean clover (*Trifolium subterraneum*, L.)[3]. The solution culture medium used in these experiments was prepared by adding highly purified inorganic salts to twice-distilled water. In addition, the plants were grown in glasshouses fitted with filters to purify the incoming air.

The economic importance of chlorine as a plant nutrient will depend on whether or not plant growth in the field is limited by chlorine deficiency. Although a great deal of information has been accumulated regarding saline soils, there is little known of the occurrence of soils very low in chlorine. As a first step in investigating this problem, I collected soil samples from various locations in California. These were selected with regard to distance from the sea, high altitude, heavy rainfall or with permeable, well-drained soil profiles. It was thought that these conditions were likely to produce soils low in chlorine. On analysis of saturation extracts by electrometric titration, the two soils lowest in chlorine were found to contain only three to five micro-equivalents per 100 gm. These soils, a Holland sandy loam and a Cometa coarse, sandy loam, were found in the foothills of the Sierra-Nevada Range at points about 65 miles apart, and 100 miles from the ocean. Both sites were carrying a poor growth of annual pasture plants.

Subterranean clover (var. Mt. Barker) was planted in 2·4-kgm. pots containing these soils, and then

Fig. 1

grown in a glasshouse at the University of California, Berkeley. To half the pots, ample chlorine for plant growth was added; in the others the only chlorine present was that in the soil. All the pots were supplied with a complete nutrient solution, lacking only in chlorine. The plants were watered with twice-distilled water. At intervals of 3–4 weeks the plants were mown back to simulate the defoliating effects of grazing.

After three and a half months, acute symptoms of chlorine deficiency were present on the 'minus-chlorine' plants on both soils, and the top yields of these plants were reduced. The type of culture technique and the yield effects on one soil type are shown in Fig. 1. Under the conditions of the experiment these soils did not contain sufficient chlorine to grow the clover plants even to the flowering stage.

A similar exploratory soil survey has now been carried out in Western Australia. Here, despite the areas of saline soils and salt lakes in the inland agricultural areas, three soils containing only 3–5 micro-equivalents of chlorine per 100 gm. were found. Two of these soils were potted in 5-kgm. containers in the glasshouse at Perth. They were then planted with subterranean clover. Again, as in the Californian trial, acute chlorine deficiency symptoms developed before the plants reached the flowering stage. In this experiment no air filters were used on the glasshouse, which stands only 150 yards from a salt-water estuary and five miles from the ocean.

The amount of chlorine present in the soils described is equivalent to about 4 lb. per acre—6 in., or the depth of the pots used. Much of the chlorine in soils is derived from the rainfall. Hence, it is of interest to note[4] that five rural areas in Victoria receive little more than this amount in the annual rainfall.

This work is continuing and will be reported in more detail elsewhere. However, it is apparent that a number of soils contain insufficient chlorine for plant growth when the plants are repeatedly defoliated under glasshouse conditions.

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Use of Loosely Linked Genes to estimate Chromatid Interference by Tetrad Analysis

STRICKLAND[1] has applied to tetrad data for *Aspergillus nidulans* the method I have suggested[2] for estimating the magnitude of chromatid interference between cross-overs when loosely linked genes are used. The principle underlying this method is as follows: Consider three linked loci X, Y and Z spaced along a chromosome in that order. By means of tetrad analysis one can distinguish a number of tetrad genotypes. Certain of these, called (*a*), (*b*) and (*c*), respectively, are most simply interpreted as resulting from the following cross-overs at meiosis: (*a*) One cross-over between X and Y and another between Y and Z involving the same chromatids, that is, a two-strand double cross-over. (*b*) One cross-over between X and Y and another between Y and Z, with a three-strand relationship. (*c*) One cross-over between X and Y and another between Y and Z involving the other two chromatids, that is, a four-strand double cross-over. With closely linked genes, the frequencies of (*a*), (*b*) and (*c*) provide accurate information about the frequencies of two-, three- and four-strand relationships between cross-overs. If the genes are loosely linked, these tetrad genotypes can also arise as a consequence of a three-strand double cross-over between X and Y (or Y and Z) and a third cross-over between Y and Z (or X and Y), but the strand-relationships with the third cross-over are two- or four-strand for genotype (*b*) and three-strand for genotypes (*a*) and (*c*). In other words, the occurrence of these triple cross-over tetrads will hinder the detection of chromatid interference by tending to obscure differences from the 1 : 2 : 1 proportion of genotypes (*a*), (*b*) and (*c*). This is the ratio expected with no chromatid interference. The frequency of these inconvenient triple cross-over tetrads can be estimated from the observed frequency of another tetrad genotype (*d*), which results from a four-strand double cross-over between X and Y (or Y and Z) and a third cross-over between Y and Z (or X and Y). In this way, allowance can be made for the effects of triple cross-overs.

If the frequencies of tetrads of genotypes (*a*), (*b*) and (*c*) do not differ significantly from a proportion of 1 : 2 : 1, there are two alternative explanations, namely, either (1) successive cross-overs occur at random (or nearly so) as regards the pair of strands involved, or (2) there is chromatid interference, but its occurrence has been obscured owing to triple cross-overs. In the latter event, analysis of a larger number of tetrads should reveal a significant deviation from 1 : 2 : 1, since only a minority of the tetrads are likely to arise from triple crossing-over. Thus, from his analysis of 264 tetrads from "cross 2", Strickland[1] obtained frequencies of genotypes (*a*), (*b*) and (*c*) of 34, 66 and 24, respectively. These frequencies do not differ significantly from a proportion of 1 : 2 : 1 ($\chi^2 = 2{\cdot}13$ $n = 2$, $P = 0{\cdot}5$–$0{\cdot}3$). There were 15 tetrads of genotype (*d*) and consequently the contribution to the (*a*), (*b*) and (*c*) genotypes due to triple cross-overs can be estimated (as a first approximation) to be $\frac{66}{24} \times 15 = 41{\cdot}25$, or 33·3 per cent. Thus it is probable that about two-thirds of the 124 tetrads of genotypes (*a*), (*b*) and (*c*) have resulted from double cross-overs and consequently have provided valid information about the strand-relationships between cross-overs. Analysis

of a larger sample of tetrads will therefore be expected to provide a significant deviation from 1 : 2 : 1 if there is chromatid interference. However, from Strickland's published data it is not justifiable to conclude that there is such interference, since hypothesis (1) above has not been ruled out. In other words, the 'correcting' of chromatid interference data to allow for triple cross-overs can be used for estimating the magnitude of such interference but not for detecting its occurrence in the first place.

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Cytochromes of *Rhizobium*

Leghæmoglobin, the red pigment associated with the bacteroid form of *Rhizobium* in effective legume root nodules, appears to be closely linked with the nitrogen fixation process[1], but its connexion with *Rhizobium* respiration is disputed[2,3]. We are endeavouring to clarify the latter problem by a comparative study of respiratory pigments in several free-living *Rhizobium* strains and the related root nodules.

While observing with a microspectroscope the reduction of leghæmoglobin in fresh homogenates of effective soybean or clover nodules made anaerobic by endogenous respiration, we saw also a sharp absorption band appearing near 551 mμ. This was later identified as the α-absorption band of reduced bacteroid cytochrome *c*, and it therefore appeared that biological reduction of the two pigments could be closely related. A smaller amount of *b*-type cytochrome, with α-absorption band at 562 mμ, was also seen in the washed bacteroids isolated from these homogenates, but no cytochrome *a* could be detected even when dense bacteroid suspensions in 50 per cent (v/v) glycerol were examined in the spectroscope at liquid air temperature (cf. Hartree[4]). Typical cytochrome *a*, *b* and *c* absorption bands as described by Smith[5] were readily observed in the same *Rhizobia* grown on an agar medium, showing that, in the transition from free-living to bacteroid form, *Rhizobium* loses its cytochrome *a*.

Many micro-organisms suffer an adaptive loss of cytochrome *a* when grown anaerobically[6], and as the nodule interior is assumed to be at a very low oxygen tension[2] we then made a quantitative comparison of cytochrome components in effective soybean nodule bacteria and the same *Rhizobium* strain grown in pure culture at high and low oxygen tensions. Cytochrome concentrations were measured in a Bellingham and Stanley reversion microspectroscope following the general procedure described by Hartree[4]. The comparison prism of this instrument was remounted so that the bacterial spectrum and the comparison spectrum (of reduced mammalian cytochrome *c* contained in a wedge-trough) were viewed simultaneously. By turning the reversion screw, the α-absorption band of the standard cytochrome *c* was matched in turn against each cytochrome band of the bacterial spectrum. An arbitrary assumption was made that the α-absorption bands of all components had the same specific extinction coefficient as cytochrome *c*.

These measurements (Table 1, *A*) showed an increase of cytochromes *b* and *c* in effective nodule bacteria (bacteroids) and cultured *Rhizobium* grown at low oxygen tension, and confirmed the complete loss of cytochrome *a* from bacteroids. Cytochrome *a* had decreased in amount, but not disappeared from the cultured organisms grown at an oxygen pressure of 0·02 atm. We were unable to grow *Rhizobium* in liquid culture at oxygen tensions lower than this and so could not decide whether the complete disappearance of cytochrome *a* from bacteroids is solely due to a very low oxygen tension inside the effective nodule. Subsequent measurements (Table 1,*B*) on *Rhizobium* isolated from ineffective soybean nodules (which were devoid of leghæmoglobin and caused no detectable nitrogen fixation), made this explanation seem unlikely, as these bacteria still contained a small amount of cytochrome *a*.

Table 1. Cytochrome Concentrations in *Rhizobium* from Artificial Culture and Nodules

Rhizobium strain (5)	Origin	Cytochrome component	α-Band (mμ)	Conc. in pellet (m*M*)	Nitrogen content (mgm./ml. of pellet)
A					
505 Wisconsin	Culture	*c*	551	0·096	38
	Oxygen pressure	*b*	562	0·036	
	=0·2 atm.	*a*	602	0·023	
505 ,,	Culture	*c*	551·5	0·160	37
	Oxygen pressure	*b*	563	0·044	
	=0·02 atm.	*a*	602·5	0·012	
505 ,,	Effective	*c*	551·5	0·270	29
	nodule	*b*	562·5	0·059	
		a	—	0	
B					
507 ,,	Culture	*c*	551·5	0·050	28
	Oxygen pressure	*b*	562·5	0·038	
	=0·2 atm.	*a*	601·5	0·021	
507 ,,	Ineffective	*c*	551·5	0·108	27
	nodule	*b*	562·5	0·033	
		a	602	0·006	

The bacteria were isolated from vigorously aerated log-phase liquid cultures and from 6–7-week-old nodules of 'Lincoln' strain soybean grown in the glasshouse. After checking for purity the washed *Rhizobium* suspensions were reduced with dithionite, and the pellets obtained after high-speed centrifuging (30,000*g*) were placed in demountable spectrophotometer cuvettes of 1, 2 or 3 mm. light path. Cytochrome contents, determined as described in the text, are expressed as millimolar concentrations in the packed pellets. Total nitrogen values were determined by the Kjeldahl method.

Work is at present in progress to determine what function cytochrome *a* has in the terminal oxidase system of *Rhizobium*[7], and whether its unique disappearance from bacteroids is accompanied by the appearance of another oxidase which might react specifically with leghæmoglobin.

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Reproductive Disturbances of Romney Ewe Lambs grazed on Red Clover (*Trifolium pratense*) Pastures

On March 10, 1958, 111 Romney ewe lambs (group *A*) which had grazed continuously since weaning (December 12, 1957) on pastures dominant in red clover were joined with an additional 92 Romney ewe lambs (group *B*) for studies of their breeding season. This latter group had grazed, since weaning (December 11, 1957), on perennial rye-grass–white clover pastures. Vasectomized, ochred rams were run with these lambs from March 17, 1958, all being grazed together on perennial rye-grass–white clover pastures. All lambs were weighed on March 19, group *A* and group *B* having the same average live weight (71 lb.). On the same day, that is, within two days of joining with teasers, 29 lambs from group *A* but none from group *B* were found to have been marked. This sudden onset of œstrus from one group of lambs was unexpected in view of the previous results[1] on the breeding season of Romney ewe lambs. Owing to the relatively early age at first œstrus shown by these lambs, laparotomy was performed within five days of observed œstrus to determine whether ovulation had occurred. Both the left and right ovaries of eight lambs were examined without finding any evidence of the existence of corpora lutea. Graafian follicles of varying sizes, however, were seen on most ovaries.

Red clover[2], like Australian subterranean clover[3], has been reported to contain substances with œstrogenic effects. In order to investigate whether the observed œstrus without ovulation in the lambs described earlier could have resulted from the œstrogenic activity of the red clover dominant pastures, random samples of this pasture were collected on March 25. These samples, consisting almost entirely of red clover, were freeze-dried, ground in a hammer mill and fed to 21-day-old, ovariectomized white mice in an attempt to detect the presence of substances with œstrogenic effects by the mouse uterine weight technique[4]. The control diet consisted of 50 per cent (by weight) barley meal and 50 per cent butter milk powder. The 'clover' diet was made up from 75 per cent (by weight) control diet and 25 per cent 'clover' pasture. Results from two feeding periods of 10 and 11 days respectively were combined and are presented in Table 1.

Table 1. The Effects of feeding 'Clover' Diet to Mice (Seven Mice per Group)

Treatments	Control	'Clover'
Initial body-wt. (gm.)	8·76	8·64
Final body-wt. (gm.)	15·10	10·07
No. of vaginal openings	1*	7
Mean and S.D. of uterine wt. (mgm.)	5·36±0·99	10·57±2·67

* Suspected to be an artefact.

These results indicate that the 'red clover' pastures contained substances which have potent œstrogenic effects. It is also probable that ingestion of 'red clover' pastures over a period of time as occurred in the present case has induced œstrus without ovulation in the lambs. It is of interest to note that Australian workers[5–7] have repeatedly pointed out that lowered fertility of breeding ewes grazing subterranean clovers was not attributable to the failure of œstrus as detected by ochred rams. If the present findings are also applicable to breeding ewes, then under certain conditions, 'œstrus without ovulation' may represent an additional complication in studies of female infertility in sheep.

Grateful acknowledgment is due to Dr. D. S. Flux, Prof. A. L. Rae and Mr. B. Thatcher for assistance and discussion.

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Molybdenum Content of Equine Liver Tissue

The discovery that molybdenum is a component of the enzyme xanthine oxidase[1] has directed interest to the presence of this element in animal tissue, particularly liver. I have found that adult horse liver tissue contains highly variable levels of molybdenum.

125 specimens of adult horse liver were obtained from a Cambridge slaughter-house during a period of eight months. The liver samples were dried at 100° C. and the dried material analysed for molybdenum by the thiocyanate–stannous chloride method of Dick and Bingley[2]. The range of molybdenum content of the tissues is shown in Fig. 1.

While 109 of the 125 livers were within the range 3–19 p.p.m., five livers had molybdenum-levels of 42·0, 47·6, 54·8, 76·4 and 84·6 p.p.m. of tissue dry-matter. The total ash contents of these latter five samples were within the normal range.

Comparing these figures with the data given by Underwood[3], it has been found that molybdenum accumulates in the liver to a greater extent in the horse than in cattle or sheep. The reason for the accumulation of this element is not known, but it is

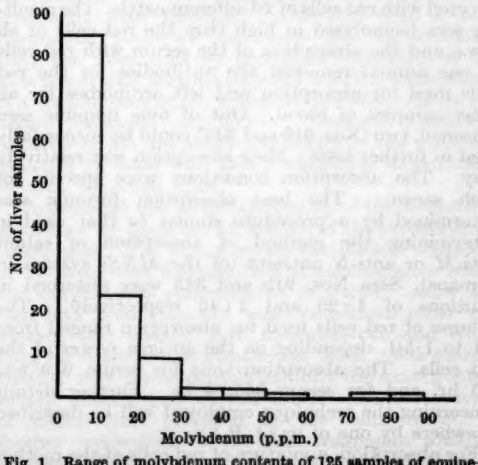

Fig. 1. Range of molybdenum contents of 125 samples of equine liver

possibly associated with the advanced age of individual animals. The rise in molybdenum may also reflect changes in the enzyme activity of the liver with age.

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Serological Test for Determination of Parentage in Cattle

The antigenic individuality of red cells of cattle was noted in 1910 [1], and studies conducted since 1940 by many workers have made it possible to identify more than fifty blood factors. The number of blood-group combinations is very large, and in practice it is difficult to find two individuals with the same combination. Identification of red cell antigens in cattle and knowledge of the mode of inheritance of these characters have been found to have a practical application among others in the exclusion of paternity and the control of pedigree. A condition for the efficacy of these tests is the possession by the laboratory of a large number of immune sera (reagents).

In 1950 Lõns[2], basing his argument on antigenic individuality of human red cells, proposed the method of determining paternity by the use of polyvalent immune serum. He assumed that the polyvalent serum absorbed by the red cells of the father and the mother would react with the red cells of all other persons with the exception of the red cells of a child of the couple the red cells of which were used for the absorption. This method did not yield the expected results and control tests proved it to be useless.

Prof. F. Milgrom suggested to us that an analogous method might be successful for the determination of parentage in cattle.

In order to obtain polyvalent sera, rabbits were injected with red cells of 20 different cattle. The resulting sera hæmolysed in high titre the red cells of all cows, and the absorption of the serum with red cells of one animal removed the antibodies for the red cells used for absorption and left antibodies for all other samples of blood. Out of nine immune sera obtained, two (Nos. 919 and 345) could be successfully used in further tests; their absorption was relatively easy. The absorption conditions were specific for each serum. The best absorption formula was determined by a procedure similar to that used in determining the method of absorption of rabbit anti-*M* or anti-*N* antisera (of the *MNSs* system in humans).[1] Sera Nos. 919 and 345 were absorbed in dilutions of 1 : 25 and 1 : 45 respectively. The volume of red cells used for absorption ranged from 1/1 to 1·5/1, depending on the antigen power of the red cells. The absorption time for serum 919 was 2·5 hr. and for serum 345, 4 hr. Further details concerning the technique employed will be described elsewhere by one of us (J. R.).

For absorption, a mixture of red cells of the mother and the father was used. After absorption, a hæmolysis test was made with the red cells of the offspring. As a control, tests were performed with red cells used for absorption and with red cells of about twenty other cattle. These red cells came from: (1) the offspring of only one of the couple the red cells of which were used for the absorption—these cattle are denoted in Table 1 as 'related'; and (2) cattle regarded as 'unrelated'. These were unrelated or showed a lesser degree of relationship than the cows in group 1. As a complement, guinea pig serum diluted 1 : 10 was used. This serum was previously controlled to see that it did not contain antibodies for cattle red cells.

Table 1. Results of Tests with the use of Two Polyvalent Sera

Material tested	Results obtained with serum No.					
	919		345		919+345 together	
	Number tested	Parentage excluded	Number tested	Parentage excluded	Number tested	Parentage excluded
Offspring	41 *1·000**	0 *0·000*	41 *1·000*	0 *0·000*	41 *1·000*	0 *0·000*
Related individuals	142 *1·000*	80 *0·563*	146 *1·000*	81 *0·554*	140 *1·000*	86 *0·614*
Unrelated individuals	663 *1·000*	528 *0·796*	662 *1·000*	527 *0·796*	650 *1·000*	579 *0·891*

* Figures in italics denote the percentage of the number tested.

After absorption the sera never reacted with the red cells employed for absorption nor did they react with the red cells of cows that were the offspring of the couple the red cells of which were employed for absorption. In contrast to this, these sera reacted with the majority of control red cells both with the samples from the 'related' and 'unrelated' heads of cattle. 35 families with 41 offspring were studied. Control tests were made with 140 'related' and 650 'unrelated' individuals. Table 1 gives the results of our tests.

From these results it appears that the use of two polyvalent sera makes possible the exclusion of about 89 cows out of 100 that were not the offspring of the couple the red cells of which were used for absorption. When the tested individual is an offspring of only one of the heads the red cells of which were used for absorption, exclusion of parentage is still possible in 61 per cent of cases. The first of the figures given, 89 per cent, is almost the same as giving positive indication of the proper pair of parents in the case when it was not possible to exclude the parentage.

It seems that the method described will be of practical use in checking doubtful parentage since the method is incomparably more simple and more within the scope of an ordinary laboratory than the method employed hitherto in which many reagents difficult to obtain are used. The efficiency of the method is quite good; this method could be increased if a third polyvalent serum were used.

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Variations in the Insecticide Tolerance of Insects

RECENT communications[1,2] on the variance of the dosage-mortality response of strains of housefly and mosquito susceptible and resistant to insecticide serve to emphasize that, although there is considerable information on the inheritance of resistance to insecticide in some insects, especially houseflies[3], *Drosophila*[4] and now mosquitoes[5], there has as yet been no direct estimate of how much of the unselected tolerance is genetically determined, how much is due to environmental effects. Beard[6], who first directed attention to the possibilities, considered the non-genetic variation might so predominate as to overwhelm the genetic components.

One would not wish to dispute the contention[1] that insect populations comprised of a single resistance-susceptibility genotype are likely to be less variable in their tolerances than are populations containing all possible resistance-susceptibility genotypes. But that fact is scarcely relevant to what Hewlett originally suggested[7], namely, that a portion of the tolerance variance is susceptible to manipulation without any change in gene frequency. That this interpretation was, at least in part, intended is shown by the example selected[8], the decrease in variance of the tolerance found with a DDT-resistant strain of housefly when increasing amounts of the insecticidally inert synergist DMC were added to the applied DDT. One point which strongly supports Hewlett's hypothesis, but has not been commented upon, is the very obvious increase in variance with the smallest amount of DMC compared with that found with DDT alone[8].

It is usual to assume that the genes for resistance are extremely rare in Nature, or, as stated by Wilson-Jones and Davidson[1], so infrequent that an average sample of wild insects is unlikely to contain resistant genes. This assumption has been made repeatedly in attempts to explain the often rather slow emergence of resistance in the field, but, as was recently pointed out[9], it is unlikely that this assumption of rarity is correct. Indeed, the only quantitative work as yet available on the frequency of resistant genes in wild populations showed that there may be as many as 12 per cent of dieldrin-resistant heterozygotes in the *Anopheles gambiae* populations of areas as yet untouched by dieldrin[10]. Finally, laboratory populations originate as samples from wild populations, most but not all attempts in the laboratory to induce insecticide resistance are successful, and sometimes resistance to a number of insecticides can be developed sequentially[11].

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Fluorescent Mast-Cell Reaction in Precancerous Skin of the Lizard *Lacerta agilis*

THE mast-cell reaction of the mouse skin, painted with tar or carcinogenic hydrocarbons, has been known for a long time[1]. According to several authors, these cells show a golden-brown fluorescence when examined under the microscope in ultra-violet light[2], though other investigations give some evidence to the contrary[3].

Recently, it has been established that the mast cells of the mouse and the rat contain not only histamine but also 5-hydroxytryptamine[4]. This substance can be converted into a fluorescent β-carboline derivative by the action of formaldehyde, and in the mast cells of the precancerous mouse skin it reaches a concentration which is normally only achieved by the cells of the enterochromaffin system[5].

In the mastocytosis of the mouse skin after painting with 9,10-dimethyl-1,2-benzanthracene in acetone it could be demonstrated to direct assay and by paper chromatographic examination that the fluorescent substance of the mastocytes is the 5-hydroxytryptamine derivative β-carboline[2].

Continuing these investigations, we examined a cutaneous carcinoma of a lower vertebrate, namely, the squamous-cell carcinoma of the lizard *Lacerta agilis*. This tumour seemed pre-eminently suitable for this purpose, because a distinct precancerous phase occurs in its development[6,7]. At first we had seven tumour-bearing animals, but by extending the material we finally had 104 specimens at our disposal.

From these specimens the precancerous portions of the skin were excised. The examination of the mast cells was carried out with frozen sections (cut in a horizontal as well as in a vertical direction), free-hand sections and tissue spreads prepared from dermal scrapings. The skin material, fixed in 10 per cent formalin or otherwise, was examined under the microscope in ultra-violet light. Then the material was stained either with acetylated sudan black for phospholipids[8] or with toluidine blue for mast cells.

Just as in the mouse, the mast cells of the precancerous skin of the lizard gave a golden-brown fluorescence in ultra-violet light, but only after treatment with formalin. The fact that a non-fluorescent precursor substance can be extracted from the mast cells by prolonged treatment of the skin tissue with acetone suggests that the fluorescence is a consequence of the action of formaldehyde on the above-mentioned substance. Acetone treatment apparently did not affect the ability of the mast cell granules to stain with either acetylated sudan black or with toluidine blue.

To establish the chemical identity of the fluorescing substance we prepared an extract of the precancerous lizard skin. For this purpose the dermal scrapings of the skins were homogenized in acetone, after which the extract was concentrated *in vacuo*. After the fats had been removed with petroleum ether the extract was treated with formaldehyde and could then be examined in ultra-violet light. The extract treated with formaldehyde exhibits the same golden-brown fluorescence as was found with the extract of mouse skin prepared in the same way[2]. A further extraction of the skin fragments with fat solvents failed to yield additional fluorescent material.

Like the mast cells of the precancerous mouse skin, the mast cells of the precancerous skin of the lizard probably contain a relatively large quantity of histamine and 5-hydroxytryptamine.

The source of 5-hydroxytryptamine is unknown; it may be either the inside or the outside of the precancerous epidermis. Possibly this substance plays an important part in the development of the squamous-cell carcinoma of the skin.

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Undergraduate Academic Record of Fellows of the Royal Society

The communication by Gross and Hudson in *Nature* of September 20, p. 787, shows an interesting difference between academic records of Fellows of the Royal Society who were respectively at Cambridge and at Oxford. Of those at Cambridge only about 77–78·5 per cent achieved a first, and in fact only about 55 per cent achieved a first in both parts of a tripos. The Fellows of the Royal Society who were at Oxford, on the other hand, graduated with first-class honours in about 97 per cent of cases.

The authors suggest that these interesting results are open to at least two interpretations: (1) that the Oxford examination is a more valid index of potential research ability; and (2) that the standards of the Oxford examinations are relatively lower than those of Cambridge. There is surely a very important third possible interpretation, namely, extra-curricular activities are far more interesting at Cambridge than at Oxford, and that in the widest sense the Cambridge education is therefore better.

The authors, strangely, make no comment on the fact that it seems to be three times as common for a Cambridge graduate to become a Fellow of the Royal Society, neither do they comment on the obvious fallacy of the whole investigation, namely, the opportunities for research offered to a young man at the beginning of his career. If these are, for example, only offered to those with a first-class degree, it is obvious that selection for the fellowship of the Royal Society in later years will be almost restricted to those who had first-class degrees. The method will fail to show whether there is a number of potentially good investigators among those with second-class degrees who have never been given the opportunities for a career in research.

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We certainly agree with Prof. Platt that the difference between the Oxford and Cambridge results is open to the third possible interpretation that he suggests, and we would welcome from him any suggestion as to how we could measure the "more interesting" nature of the "extra-curricular activities" at Cambridge.

We find nothing strange in "the fact that it seems to be three times as common for a Cambridge graduate to become a Fellow of the Royal Society" since there are almost three times as many science graduates from Cambridge as there are from Oxford.

During the period 1920–39, approximately 4,700 natural scientists, 1,400 mathematicians and 1,800 engineers graduated from Cambridge, while only 2,600 natural scientists (including engineers) and 400 mathematicians graduated from Oxford.

If we understand Prof. Platt's last paragraph correctly, we consider it to be true but irrelevant to our study and to the general problem under consideration. Obviously, as he points out, if only students with first-class degrees are given opportunities for research, the Fellows of the Royal Society will be drawn largely from this group. Our point is that, whatever selection procedures were used in the past, a considerable minority of the scientists elected to the Royal Society did not receive first-class degrees. From this we conclude that it may be unwise to use class of degree as the primary criterion for the award of research grants.

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Cancer and Smoking

In a letter published in *Nature* of August 30, p. 596, Sir Ronald Fisher quoted figures confirming previous observations that smoking habits are more similar in identical than in fraternal pairs of twins even when the identical pairs are reared apart. The result can be interpreted as showing that, like almost every trait, mental or physical, previously tested by the twin method, smoking habits are, to a greater or lesser degree, dependent upon genetical constitution. It is, however, difficult to appreciate the relevance of this demonstration to the problem as to whether or not cigarette smoking causes lung cancer.

The association between epithelioma and the occupation of sweeping chimneys has been well known in the past. Not improbably it could have been proved that identical twins were more often both chimney sweeps than would have been expected by chance. Such a finding would not have influenced the case for assuming a strong causal connexion between soot irritation and epithelioma.

Nevertheless, there are perhaps hitherto unexplored ways in which twin data might be usefully employed in the study of the effects of tobacco on the lungs. Pairs of identical twins, whose smoking habits were discordant, could be followed up with special reference to possible development of lung disorders in one or both members.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 27

INSTITUTE OF ACTUARIES (in Staple Inn Hall, High Holborn, London, W.C.1), at 5 p.m.—Mr. F. M. Redlington: Presidential Address.

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. A. T. Grove: "Geomorphology of the Tibesti Region".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. J. Swaffield and Mr. D. L. Richards: "Rating of Speech Links and Performance of Telephone Networks"; Mr. D. L. Richards and Dr. J. Swaffield: "Assessment of Speech Communication Links".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. D. J. Farrar: "The Bloodhound".

Tuesday, October 28

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. J. Z. Young, F.R.S.: "Octopuses, Squids and Cuttlefishes".*

UNIVERSITY OF LONDON (at Queen Mary College, Mile End Road, London, E.1), at 1.30 p.m.—Prof. G. E. Newell: "The History of a Beach".*

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 2 p.m.—Symposium on "Aluminium Pressure Vessels".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Electronic Control of Machine Tools" opened by Mr. D. T. N. Williamson.

UNIVERSITY OF LONDON (in the main Chemistry Theatre, Royal College of Science, Imperial College of Science and Technology, London, S.W.7), at 5.30 p.m.—Dr. H. Zemanek (Vienna): "Some Automata of the 18th Century".*

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, Portland Place, London, W.1), at 6 p.m.—Dr. L. Essen: "Basic Measurements of Time and Frequency".

PLASTICS INSTITUTE, LONDON AND DISTRICT SECTION (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Mr. B. S. Dyer: "Vinyl Chloride Polymers—Their Design and Application".

INSTITUTION OF ELECTRONICS (in the Assembly Hall of the University of London Institute of Education, Malet Street, London, W.C.1), at 7 p.m.—Dr. F. E. Flood: "Electronic Telephone Exchanges".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at the Medway College of Technology, Maidstone Road, Chatham, Kent), at 7.30 p.m.—Prof. R. S. Nyholm, F.R.S.: "Recent Advances in Structural Inorganic Chemistry".

Wednesday, October 29

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. P. Fourman: "Magnesium Metabolism".*

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP—NUTRITIONAL PANEL (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Meeting on "Nutritional Problems in Polar Regions". Lieutenant Commander A. B. Erskine, R.N.: "Sledging Problems"; Major J. M. Adam, R.A.M.C.: "Use of M.R.C. Sledging Rations".

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Dr. M. Prutton: "Ferro-Electrics and Computer Storage".

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 6.30 p.m.—Programme of Scientific Films pertaining to Atomic Energy. "The Dounreay Sphere"; "Engineering at Calder Hall"; "Criticality".

BRITISH ASSOCIATION OF CHEMISTS (at the Royal Society of Medicine (West Hall), 1 Wimpole Street, London, W.1), at 7 p.m.—Mr. J. Wilson: "Grant-Aided Research Associations" (Hinchley Memorial Address).

Thursday, October 30

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. L. B. Keeble: "The Role of Town Planning in Modern Society".*

Friday, October 31

INSTITUTION OF MECHANICAL ENGINEERS (in conjunction with the APPLIED MECHANICS GROUP, at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. W. Johnson: "Estimation of Upper Bound Loads for Extrusion and Coining Operations".

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-upon-Tyne), at 6.15 p.m.—Sir John Cockcroft, O.M., F.R.S.: "Nuclear Power for the Propulsion of Commercial Shipping" (Andrew Laing Lecture).

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. J. D. Bernal, F.R.S.: "The Structure of Liquids".

Saturday, November 1

MAMMAL SOCIETY OF THE BRITISH ISLES (in the Meeting Room of the Zoological Society of London, Regent's Park, London, N.W.1), at 10.30 a.m.—Symposium on "Mammals in British History and Prehistory".*

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. C. P. Mountford: "The Aborigines of the Central Australian Deserts".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ADVISORY OFFICER (with a degree in science or agriculture, preferably with honours, and experience in investigations or research concerning poultry husbandry) IN POULTRY HUSBANDRY—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (October 31).

EXPERIMENTAL PHYSICISTS (preferably with an honours degree in physics or equivalent and a sound experimental physics background) IN THE RESEARCH AND DEVELOPMENT DEPARTMENT, Central Electricity Generating Board for work on nuclear reactors, particularly on experimental reactor physics during the commissioning of civil nuclear power stations—The Personnel Officer, Central Electricity Generating Board, 24–30 Holborn, London, E.C.1, marking envelope "Confidential —Ref. N/308" (November 3).

READER (with high academic and research qualifications) IN THE DEPARTMENT OF PHYSICS; and a LECTURER or ASSISTANT, Grade B (preferably with teaching and research experience), IN THE DEPARTMENT OF PHYSICS—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (November 7).

ASSISTANT EXPERIMENTAL OFFICER (with a pass degree or equivalent) IN THE DEPARTMENT OF PHYSIOLOGY AND PLANT CULTURE, for duties concerned with day-to-day routine work on plant studies in controlled environments—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford (November 8).

ASSISTANT IN THE DEPARTMENT OF BOTANY—The Secretary, The University, Edinburgh (November 8).

ASSISTANT LIBRARIAN (honours graduate) IN THE SCIENCE SECTION of the College Library—The Registrar, University College of North Wales, Bangor, North Wales (November 8).

LECTURER or ASSISTANT LECTURER IN SOCIOLOGY (with special reference to SOCIAL ANTHROPOLOGY)—The Secretary, The University, Exeter (November 8).

TECHNICAL OFFICER (MASS SPECTROMETER) (with a degree or diploma in chemistry or physics or equivalent qualifications) IN THE SCHOOL OF CHEMISTRY, New South Wales University of Technology, Kensington, N.S.W., Australia, to maintain and operate a MS2 Metropolitan Vickers Mass Spectrometer—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (Australia, November 12).

CHAIRS IN BOTANY, CHEMISTRY, MATHEMATICS, PHYSICS, and ZOOLOGY in the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 15).

LECTURER IN THE DEPARTMENT OF SOCIAL ANTHROPOLOGY, School of African Studies, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, November 15).

SCIENTIFIC OFFICER (with a first- or second-class honours degree in biochemistry or a closely related subject, and preferably some research experience) IN THE DEPARTMENT OF BIOCHEMISTRY, to engage in the study of problems of plant biochemistry, in particular the influence of mineral nutrition on the enzyme content of leaves—The Secretary, The Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen (November 17).

LECTURER IN CIVIL ENGINEERING at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 29).

SENIOR LECTURER or LECTURER IN MECHANICAL ENGINEERING at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 29).

LECTURER (with a degree in mechanical engineering of a recognized Commonwealth university, preferably at honours standard, or an equivalent qualification, and preferably experience of modern drawing office practice) IN MECHANICAL ENGINEERING at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, November 30).

SENIOR LECTURER and LECTURER IN GEOLOGY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 30).

ASSISTANT, Grade B (graduate well qualified in mathematics) IN MATHEMATICS—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham, Essex.

ASSISTANT LECTURER, Grade B (with a good honours degree and preferably some teaching experience) IN CHEMISTRY at Brighton Technical College, to teach general chemistry up to G.C.E. advanced level standard and to assist with the teaching of inorganic chemistry at degree level—The Director of Education, County Borough of Brighton Education Committee, 54 Old Steine, Brighton, Sussex.

BIOCHEMIST, Senior or Basic grade (with a B.Sc. degree with honours in chemistry or biochemistry or an equivalent qualification)—The Group Secretary, Royal Hospital, Wolverhampton.

BIOMETRICIAN (graduate in mathematics with an interest in biology) IN THE SECTION OF STATISTICS, for duties which involve consultation on research on the design and analyses of experiments—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, Berks, quoting Ref. 58/17.

CHEMIST (with a Ph.D. or good honours degree, and preferably experience in, or knowledge of, electro, surface or theoretical organic chemistry), to join a team investigating the fundamentals of corrosion —The Director, Arthur D. Little Research Institute, Inveresk Gate, Musselburgh, Midlothian, Scotland.

EXPERIMENTAL OFFICERS (at least 26 years of age with the H.N.C., or equivalent, in applied physics), to carry out experimental work in support of a programme of development of high speed trigatrons and associated circuitry—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. A.1968/1/34.

LECTURER IN THE DEPARTMENT OF MINING AND FUELS, for duties mainly concerned with the teaching of fluid mechanics and mine ventilation—The Registrar, The University, Nottingham.

LECTURER (with a degree in horticulture) IN HORTICULTURE at Massey Agricultural College (University of New Zealand), Palmerston North, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

LECTURER (with an honours degree in chemistry and postgraduate experience of academic or industrial research) IN PHYSICAL AND INORGANIC CHEMISTRY—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

MULLARD RESEARCH FELLOW (with a good degree in electrical engineering or physics of a British university or equivalent qualification) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, for work on microwaves—The Secretary, University College, Gower Street, London, W.C.1.

PUBLICATIONS EDITOR/LIBRARIAN (with an honours degree in arts or science, some editorial experience, an interest in agricultural research, and preferably previous library experience or training and a knowledge of one or more foreign languages)—The Secretary, Grassland Research Institute, Hurley, near Maidenhead, Berks.

RESEARCH ASSISTANT IN CHEMISTRY, to work in the field of complex metal reactions—The Secretary, Department of Chemistry, University College, Gower Street, London, W.C.1.

SEED MYCOLOGIST (with a degree in botany and preferably some postgraduate training); and a RESEARCH ASSISTANT (with a degree in botany), for work on cereal germination—The Secretary, National Institute of Agricultural Botany, Huntington Road, Cambridge.

SENIOR LECTURER IN INORGANIC CHEMISTRY, to plan and supervise the teaching of inorganic chemistry up to honours degree standard—The Principal, Royal Technical College, Salford.

SENIOR RESEARCH ASSISTANT (Ph.D. standard and preferably some experience of electronics) IN PHYSICS, for a programme of work on the magnetic properties of thin films—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey.

TECHNICIAN IN THE NUCLEAR ENGINEERING LABORATORY, for research work in electronics and nucleonics—The Registrar (NT), Queen Mary College (University of London), Mile End Road, London, E.1.

TECHNICIAN OR JUNIOR TECHNICIAN, for biochemical work in the Hospital Metabolic Unit—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2.

ZOOLOGIST OR PHYSIOLOGIST (with a degree), to assist in the British Empire Cancer Campaign research on the biology of cancer including tissue culture—The Administrative Office, Mount Vernon Hospital, Northwood, Middx.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 986, Vol. 250 (21 August 1958): Geomagnetic Dynamos. By A. Herzenberg. Pp. 543–585 (London: Royal Society, 1958.) 13*s*. [228

The Lambeth Conference 1958. The Encyclical Letter from the Bishops together with the Resolutions and Reports. Pp. 17. (London: S.P.C.K.; Greenwich, Conn.: Seabury Press, 1958.) 7*s*. 6*d*. [298

The Supply of Teachers in the 1960's—Correspondence between the Chairman of the National Advisory Council on the Training and Supply of Teachers and the Minister of Education, July 1958. Pp. 12. (London: H.M. Stationery Office, 1958.) 9*d*. net. [298

Sixth Report from the Select Committee on Estimates together with the Proceedings of the Committee, Session 1957–58—Treasury Control of Expenditure. Pp. 42. (London: H.M. Stationery Office, 1958.) 2*s*. net. [298

Pyrethrum Facts, 1958 Edition. Pp. 12. (London: Press and Public Relations, Ltd., 1958. Issued on behalf of The Pyrethrum Board of Kenya; The Pyrethrum Board of Tanganyika; and the Société Coopérative des Produits Agricoles.) [119

Leicester Museums and Art Gallery. A Catalogue of the Ophthalmosauridae in the Collections of the Leicester and Peterborough Museums. By R. M. Appleby. Pp. 47+7 plates. (Leicester: The Museums and Art Gallery, 1958.) [119

Anti-Locust Bulletin 31: Ecological Studies on Oviposition by Swarms of the Desert Locust (*Schistocerca gregaria* Forskål) in Eastern Africa. By G. B. Popov. Pp. ii+70 (51 figures). (London: Anti-Locust Research Centre, 1958.) 15*s*. [119

Siemens Edison Swan Journal, Vol. 1, Summer 1958. Pp. 1–64. (London: Siemens Edison Swan, Ltd., 1958.) [119

Platinum in the Glass Industry: a General Survey. Pp. 45. (London: The Mond Nickel Company, Ltd., 1958.) [129

Ciba (A.R.L.) Ltd. Technical Notes No. 189 (September, 1958): Laminated Beams for a Grandstand. Pp. 6. (Duxford: Ciba (A.R.L.) Ltd., 1958.) [129

Careers in Plastics. Pp. 20. (London: The Plastics Institute, 1958.) [129

Ministry of Agriculture, Fisheries and Food. Field Beans. By M. H. R. Soper. Pp. v+15+4 plates. (London: H.M. Stationery Office, 1958.) 1*s*. 9*d*. net. [129

London School of Hygiene and Tropical Medicine, incorporating the Ross Institute (University of London). Report of the Thirty-second Meeting of the Ross Institute Industrial Advisory Committee. Pp. 19. (London: London School of Hygiene and Tropical Medicine, Ross Institute, 1958.) [129

Other Countries

Regional Research Centre of the British Caribbean at the Imperial College of Tropical Agriculture, Trinidad, B.W.I. Soil and Land-Use Surveys. No. 1: Jamaica—Parish of St. Catherine. By K. C. Vernon. Pp. 42. 20*s*. No. 2: British Guiana—The Rupununi Savannas. By R. F. Loxton, G. K. Rutherford and J. Spector. Pp. 33. 15*s*. (Trinidad: Imperial College of Tropical Agriculture, 1958.) [119

United States Department of Agriculture: Agricultural Research Service. Agriculture Handbook No. 136: Estimating the Amount of Crop Residue on a Field. By F. L. Dudley. Pp. 31. (Washington, D.C.: Government Printing Office, 1958.) 15 cents. [119

Annual Report of the Director of the Museum of Comparative Zoology at Harvard College, 1956–1957. Pp. 24. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1958.) [119

Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. 119, No. 1: Revision of Five African Snake Genera. By Arthur Loveridge. Pp. 198. Vol. 119, No. 2: Four New Rajids from the Gulf of Mexico. By Henry B. Bigelow and William C. Schroeder. Pp. 199–234. Vol. 119, No. 3: The General Histology and Topographic Microanatomy of *Australorbis glabratus*. By Chia-Tung Pan. Pp. 235–300+18 plates. Vol. 119, No. 4: Studies on the Ant Fauna of Melanesia. 3: Rhytidoponera in Western Melanesia and the Moluccas. 4: The Tribe Ponerini. By E. O. Wilson. Pp. 301–372. Vol. 119, No. 5: A New Species of Chelid Turtle, *Phrynops* (Batrachemys) Dahli, from Colombia. By Rainer Zangerl and Fred Medem. Pp. 373–390+2 plates. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1958.) [119

Museum of Comparative Zoology at Harvard College. Breviora. No. 89 (July 15, 1958): Remarks on Some Forms of *Cinclus* (Aves). By James C. Greenway, Jr., and Charles Vaurie. Pp. 10. No. 90 (July 30, 1958): A Fossil Vampire from Cuba. By Karl F. Koopman. Pp. 4+1 plate. No. 91 (August 13, 1958): Contribution to a Revision of the Earth-Worm Family Lumbricidae. 2: Indian Species. By G. E. Gates. Pp. 16. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1958.) [119

Commonwealth of Australia. Ninth Annual Report of the Commonwealth Scientific and Industrial Research Organization for year 1956–57. Pp. 179. (Canberra: Government Printer, 1957.) 10*s*. 6*d*. [119

Tanganyika: Department of Geological Survey. Annual Report of the Geological Survey Department 1957. Pp. i+18. Shs. 2/50. Short Paper No. 24: Geology and Gold Deposits of the Ruvu River Area. By Dr. B. N. Temperley. Pp. iv+37+7 plates. Shs. 10. Map 1118: Nachingwea (Ruponda). (Dar-es-Salaam: Government Printer, 1957 and 1958.) [119

World Health Organization. Monograph Series No. 38: Insecticide Resistance in Arthropods. By Dr. A. W. A. Brown. Pp. 240. 15 Swiss francs; 25*s*.; 5 dollars. International Standards for Drinking Water. Pp. 152. 12 Swiss francs; 20*s*.; 4 dollars. Publications of the World Health Organization 1947–1957: a Bibliography. Pp. 128. 10 Swiss francs; 17*s*. 6*d*.; 3.25 dollars. (Geneva: World Health Organization; London: H.M. Stationery Office, 1958.) [119

Canada. Department of Mines and Technical Surveys. Geological Survey of Canada. Memoir 295: Carboniferous Stratigraphy and Rugose Coral Faunas of Northeastern British Columbia. By P. K. Sutherland. Pp. vi+177 (33 plates). 2 dollars. Bulletin 39: Soil Analyses as a Method of Geochemical Prospecting in Keno Hill-Galena Hill Area, Yukon Territory. By Robert W. Boyle and C. Brian Cragg. Pp. v+27. 50 cents. (Ottawa: Queen's Printer, 1957 and 1958.) [119

History of Botanical Researches in India, Burma and Ceylon. By Prof. S. N. Das Gupta. Part 1: Mycology and Plant Pathology. Pp. iv+118. (Madras: Indian Botanical Society, 1958.) Rs. 5.00. [119

European Productivity Agency of the Organization for European Economic Co-operation. Control of Diseases in Cattle and Sheep at Pasture. (Project No. 204.) Pp. 160. 550 French francs; 9*s*.; 1.50 dollars. Farm Management: Manual on the Preparation of National and Regional Handbooks for Use in Farm Management Advisory Work. (Project 395/1.) Pp. 156. 650 French francs; 10*s*. 6*d*.; 2 dollars. Marketing and Distribution of Meat and Dairy Products in the United States: Report of a Mission to the United States sponsored by the European Productivity Agency under Project No. 285/2. Pp. 114. 400 French francs; 6*s*. 6*d*.; 1.25 dollars. (Paris: European Productivity Agency of the Organization for European Economic Co-operation; London: H.M. Stationery Office, 1958.) [119

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